

S u m m a r y ▼

This report comprises a discussion of preferred design practices of operating companies on illumination of outdoor substations. It is based on data obtained from a questionnaire sent to committee members. There are included also data submitted by manufacturers of outdoor substation lighting equipment.

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OUTDOOR ▼ ▼ ▼
SUBSTATION ▼ ▼
ILLUMINATION ▼

A Report of the ▼ ▼

Electrical Apparatus Committee,
Engineering National Section

National Electric Light Association

FOUR-TWENTY LEXINGTON AVENUE, NEW YORK, N. Y., U. S. A.

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APPENDIX

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Outdoor Substation Illumination

Design Practices of Operating Companies

Summary

General

1. Outdoor substation illumination design has the primary purpose of making the substation equipment adequately illuminated at night for convenient and safe operation and maintenance and without undue glare. It may also have considerable advertising value for the utility company.

2. The more common types of illumination used are: inverted lighting, which throws the light generally upward and outward from relatively low post or bracket mounted units; overhead lighting, which throws the light generally downward and outward from units mounted high on the substation structures; and floodlighting, which focuses the light on the important operating equipment in the substation, usually from supports, separate from but adjacent to the substation structure. Often combinations of the three types of lighting are used. These different methods are clearly described and illustrated in detail by the various data submitted by manufacturers of lighting equipment.

3. Lighting practice varies to a considerable extent with the type of substation in relation to the transmission system. For the purpose of this report typical substation types are designated as Class I, a large step-up transforming and switching substation located adjacent to a generating station; Class II, a large transforming and switching substation located on the transmission system remote from a generating station; and Class III, a small rural transformer substation.

Lighting Supply Equipment

1. For Class I substations, lighting supply transformers are generally single phase, 3 wire, 115/230 v, and they usually do not serve any load other than lighting. For Classes II and III, lighting supply transformers are usually either single phase, 3 wire, 115/230 v, or 3 phase closed delta, 115 v, and they usually supply both light and power. The majority are using lamps having same rated voltage as the lighting transformer secondary.

2. In Classes I and II, the majority use emergency lighting circuits sepa-

rate from the normal lighting circuits and the emergency source is from a 125 volt battery. However, a considerable number have no emergency lighting, and this is usual in Class III.

3. The majority use indoor type lighting control cabinets located either in the generating station or in the substation control house. Outdoor substation lighting is usually controlled manually, seldom automatically.

Lighting Units

1. The average mounting height above grade for the lighting units is approximately 15 ft for brackets and approximately 11 ft for posts in Classes I and II; and slightly lower in each case for Class III.

2. The most common wattage sizes for lamps are 200, 300 and 500 for the inverted and overhead systems, and 300, 500 and 1,000 for floodlighting.

3. The lighting intensity in foot candles on the major electrical equipment (on vertical plane) is generally between 1 and 5 fc, although some substations in Classes I and II use between 5 and 10 fc and some substations in Class III use as low as 0.25 fc.

4. The lighting intensity in foot candles on the ground (on horizontal plane) is generally between 0.1 and 2 fc, although some substations in Classes I and II use between 2 and 5 fc and some substations in Class III use as low as 0.1 fc.

5. The practice of the majority is to normally light all substation lights all night for Classes I and II, and to light substation lights only for inspection and maintenance or during switching for Class III.

Substation Receptacle Outlets

The use of 115 v, single phase receptacles in the substation for hand lamps or small portable motors is almost universal, although in Class III receptacles are sometimes not provided. These receptacles are usually mounted directly on substation structures, and spaced approximately 50 ft, and are fed, in the majority of cases, from circuits separate from the adjacent lighting circuits.

Manhole Lighting and Outlets

The use of permanent lighting in power and control cable manholes is

confined to a few substations in Class I, but where provided, usually both lighting and receptacle outlets in the manholes are used.

Lighting Cables

Lighting cables are rubber covered, lead covered, installed in fiber or iron ducts, in the majority of cases for all classes of substations, but there is a considerable use of "Parkway" cable laid directly in the ground, sometimes protected with creosoted wooden planks. The majority use braided cable in the lighting post from the ground to the lighting unit, or braided cable in conduit on the structure.

Questionnaire on Design Practice

Data on which the foregoing summary is based, and which is given in greater detail, divided into the 3 classes, I, II and III previously defined, is given on the following pages, and was obtained by the committee through a questionnaire asking for the latest preferred design practices in outdoor substation illumination. This questionnaire was addressed to members of the Electrical Apparatus Committee known to be concerned or interested in substation illumination design.

Summary of Answers to Questionnaire on Design Practices of Operating Companies

CLASS I

A Large Step-up Transforming and Switching Substation, Located Adjacent to a Generating Station.

General

1 What is the substation nominal voltage?

1—13.2 kv 7—66 kv 6—132 kv
1—22 kv 4—110 kv 2—220 kv

2 What is the type of substation structure (wood, steel, "Flat" or "Truss" etc.)?

All use steel structures.

18 "Truss" type, 3 "Flat" type.

Lighting Supply Equipment

1 Is the lighting wiring system 2 or 3 wire?

15 use 3 wire, 6 use 2 wire.

2 Is the normal lighting circuit or circuits alternating or direct current and what is the voltage?

All use alternating current.

- 4—110/220 v, 3 wire.
- 4—115 v, 2 wire.
- 5—115/230 v, 3 wire.
- 1—120 v, 2 wire.
- 4—120/240 v, 3 wire.
- 2—125/250 v, 3 wire.
- 1—230 v, 2 wire.

3 Is the emergency lighting circuit the same as the normal circuit with a separate emergency source of power, alternating or direct current, or is the emergency lighting circuit an entirely separate circuit, alternating or direct current?

8—Use separate emergency circuits and direct current emergency source.

8—Use no emergency lighting.

5—Use same circuits and separate alternating current emergency source.

4 How are the transformers connected? (Open or closed delta, 3 wire, etc.?)

- 15—Use single phase, 3 wire.
- 2—Use single phase, 2 wire.
- 2—Use open delta, 3 wire.
- 1—Uses closed delta.
- 1—Uses Scott, 3 wire.

5 Do the above transformers serve any load other than lighting?

- 14—Use the transformers for lighting only.
- 7—Use the transformers for light and power.

6 What is the voltage of battery used for normal or emergency lighting?

- 7—Use 125 v station control battery.
- 1—Uses 250 v station control battery.

7 Does the above battery serve any other load?

Yes, also station control service load.

8 What type of outdoor lighting control cabinets are used?

13—Use cabinets located in the generating station.

8—Use outdoor type cabinets, of which 3 have remote controlled contactors connected in the lighting mains feeding the different lighting cabinets. The contactors are controlled by push button stations located either at the substation structures or in the station main control room.

Lighting Units

1 Is floodlighting, or overhead or inverted lighting system used?

- 9—Use inverted.
- 5—Use inverted and overhead combined.

1—Uses inverted and floodlighting combined.

3—Use overhead.

2—Use overhead and floodlighting combined.

1—Uses floodlighting.

2 How many units are normally lighted?

11—All units lighted.

5—No units lighted (inspection only).

3—Part of the units lighted.

3 What is the approximate time when the lights are turned on and off?

14—Have all lights on all night.

5—Have lights on only during switching or inspection.

1—Has all lights on until midnight and part on from midnight until daylight.

4 Are the lights turned on and off automatically or manually?

All turn the lights on manually.

5 What is the type and location of the lighting control switch?

18—Use lighting cabinets or lighting panels.

3—Use push button stations for remote control of contactor in the main circuit feeding the cabinets.

6 Are the units mounted on the substation structure by brackets or on separate posts or in some other manner?

9—Use brackets.

7—Use brackets and posts.

5—Use posts.

7 What is the wattage and voltage of lamps used?

(a) For inverted system, 1 uses 200 w, 3 use 300 w, 2 use 300 w for emergency and 500 w for normal lighting, and 3 use 500 w lamps.

(b) For inverted and overhead system, 300 and 500 w are used for inverted and 150, 200, 300 and 500 w are used for overhead.

(c) For inverted and floodlight systems, 1 uses 300 w for inverted and 1,000 w lamps for floodlights.

(d) For overhead system, 1 uses 300 w and 1 uses 500 w lamps.

(e) For overhead and floodlight system, 2 use 100 w for overhead and 500 w lamps for floodlight.

(f) For floodlighting, 1 uses 500 w lamps.

19—Use same voltage lamps as their transformer secondary voltage.

1—Uses 115 v lamps on 110 v circuits.

1—Uses 120 v lamps on 115 v circuits.

1—Uses 130 v lamps on 110 v circuits.

8 What is the mounting heights above grade?

Electrical Apparatus Committee

Average approx. 15 ft for brackets and 11 ft for posts.

9 What is the approximate lighting intensity in foot candles on the major electrical equipment (on vertical plane)?

7—Use from 1 to 5 fc.

4—Use from 5 to 10 fc.

10 What is the approximate lighting intensity in foot candles on the ground (on horizontal plane)?

8—Use from 0.1 to 2 fc.

4—Use from 2 to 5 fc.

Substation Receptacle Outlets

1 Do you provide receptacles in the substation for hand lamps or small portable motors?

All provide receptacles.

2 Are the receptacles mounted on the substation structure, or on lighting posts or in some other manner?

19—Mount receptacles on the structures.

2—Mount receptacles on the lighting posts.

3 What is the average spacing of receptacles?

Approximately 50 ft.

4 Is the receptacle wiring system single or 3 phase and what voltage?

13—Use single phase, 115 v.

5—Use both 115 v, single phase and 230 v, 3 phase.

1—Uses single phase, 230 v.

5 Is the receptacle fed from the same branch circuit as the adjacent lighting units or is it connected to a separate circuit?

13—Use separate circuits.

7—Use the same circuit as lighting.

Manhole Lighting and Outlets

1 Do you install permanent lighting in your power and control cable manholes?

16—Do not install permanent lighting.

5—Do install permanent lighting.

2 Are lighting fixtures, or receptacle outlets, or both, provided in manholes?

4—Use both lighting fixture and receptacle.

1—Uses lighting fixture only.

3 What is the type and location of the manhole control switch?

2—Use switch at the fixture and in the lighting cabinets.

1—Uses switch in lighting cabinet only.

4 Are the manhole lighting fixture and receptacle fed from the same branch circuit, or are manhole lights con-

nected to one circuit and manhole receptacles to a separate circuit?

2—Use the same circuit.

1—Uses separate circuit.

Lighting Cables

1 What is the cable size, type, insulation and covering used for feeding the lighting units and receptacles?

12—Use No. 6, 8, 10 or 12 rubber covered, lead covered cable.

5—Use No. 6, 8 or 10 rubber covered, lead covered, "Parkway" cable.

2—Use No. 8, 10 or 12 "Kerite" cable.

2—Use No. 6, 8, 10 or 12 rubber covered, braided cable.

2 Are the lighting cables installed in fiber or iron ducts, armored cable laid directly in ground, or installed in some other manner?

Lead covered cable is installed in fiber and iron ducts. "Parkway" cable is laid directly in the ground. "Kerite" cable is installed in iron conduit, underground and overhead. Rubber covered, braided cable is installed in exposed conduits and lighting posts and brackets.

3 How is the cable protected if laid directly in the ground?

3—Use no covering over "Parkway" cable.

2—Use creosoted wooden planks over "Parkway" cable.

4 Is braided or lead covered cable used from the ground to the lighting unit?

15—Use braided cable.

4—Use lead covered cable.

5 How are the lighting fixtures grounded?

19—Use no special grounding, but mount fixtures on grounded steel structures or connect them to conduit system.

2—Connect the lighting post bases to the station grounding system.

6 What provisions are made for grounding portable hand lamps, etc.?

20—Make no provision.

1—Uses a separate No. 8 all-rubber insulated wire, permanently attached to appliance. A test clip on the other end of the wire is clamped to the nearest ground.

The following twenty-three (23) companies contributed data on illumination design for outdoor substations in Class I, a large step-up transforming

and switching substation, located adjacent to a generating station.

Central Arizona Light and Power Company

Cleveland Electric Illuminating Company

Consumers Power Company

Dallas Power and Light Company

Deepwater Operating Company

The Detroit Edison Company

Electric Bond and Share Company

Gatineau Power Company

Georgia Power Company

Houston Lighting and Power Company

Kansas Gas and Electric Company

Louisiana Steam Products, Inc.

Milwaukee Electric Railway and Light Company

Montaup Electric Company

Oklahoma Gas and Electric Company

Pennsylvania Power and Light Company

Public Service Company of Colorado

Public Service Company of Northern Illinois

Public Service Electric and Gas

Company of New Jersey

Susquehanna Electric Company

Turners Falls Power and Electric Company

Union Gas and Electric Company

Washington Water Power Company

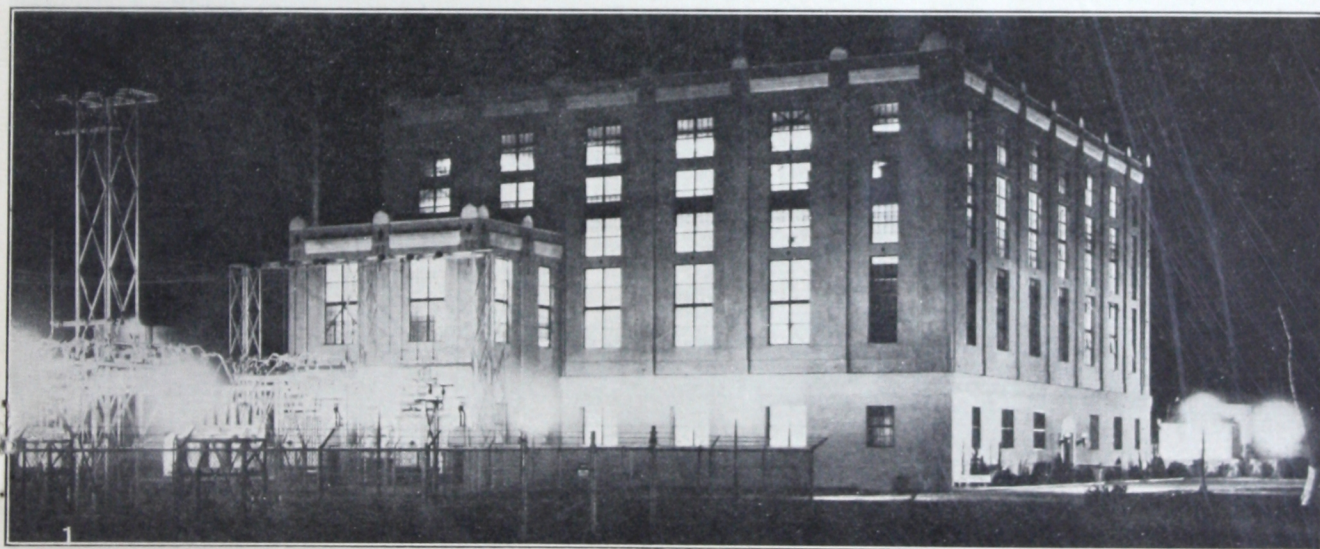


Fig. 1—Night View, Central Arizona Steam Electric Station and 12 Kv Switchyard
Central Arizona Light and Power Company

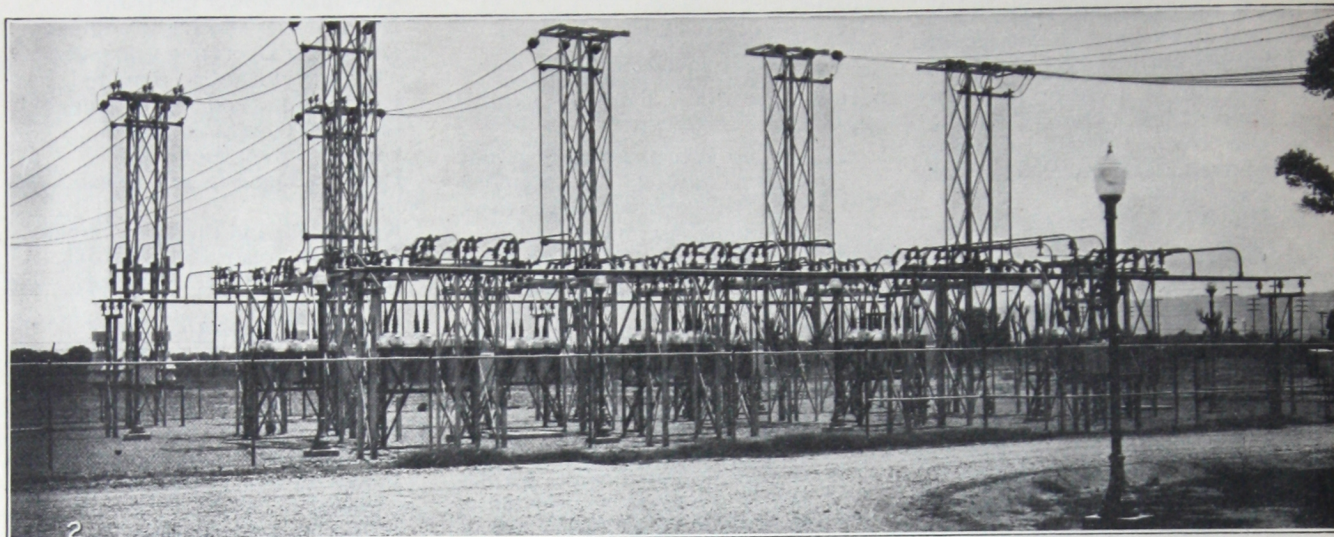


Fig. 2—Day View, 12 Kv Switchyard—Central Arizona Light and Power Company

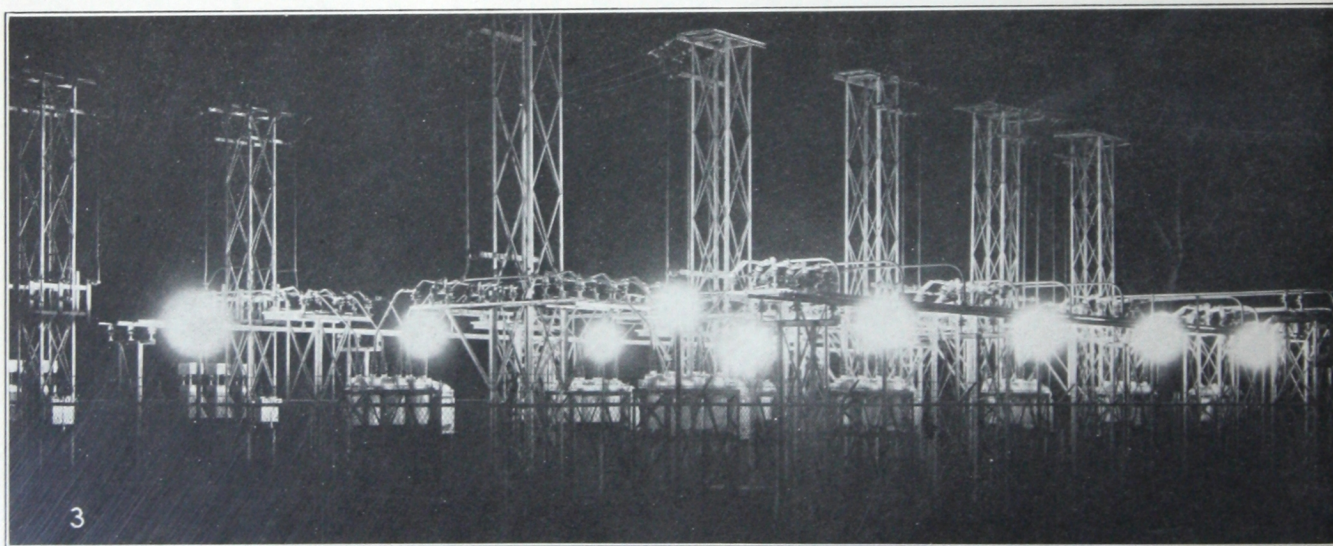
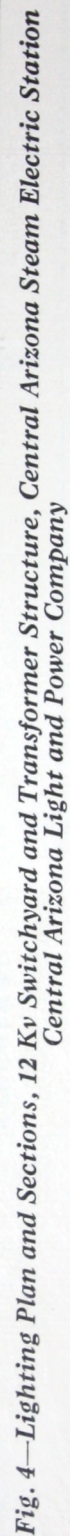
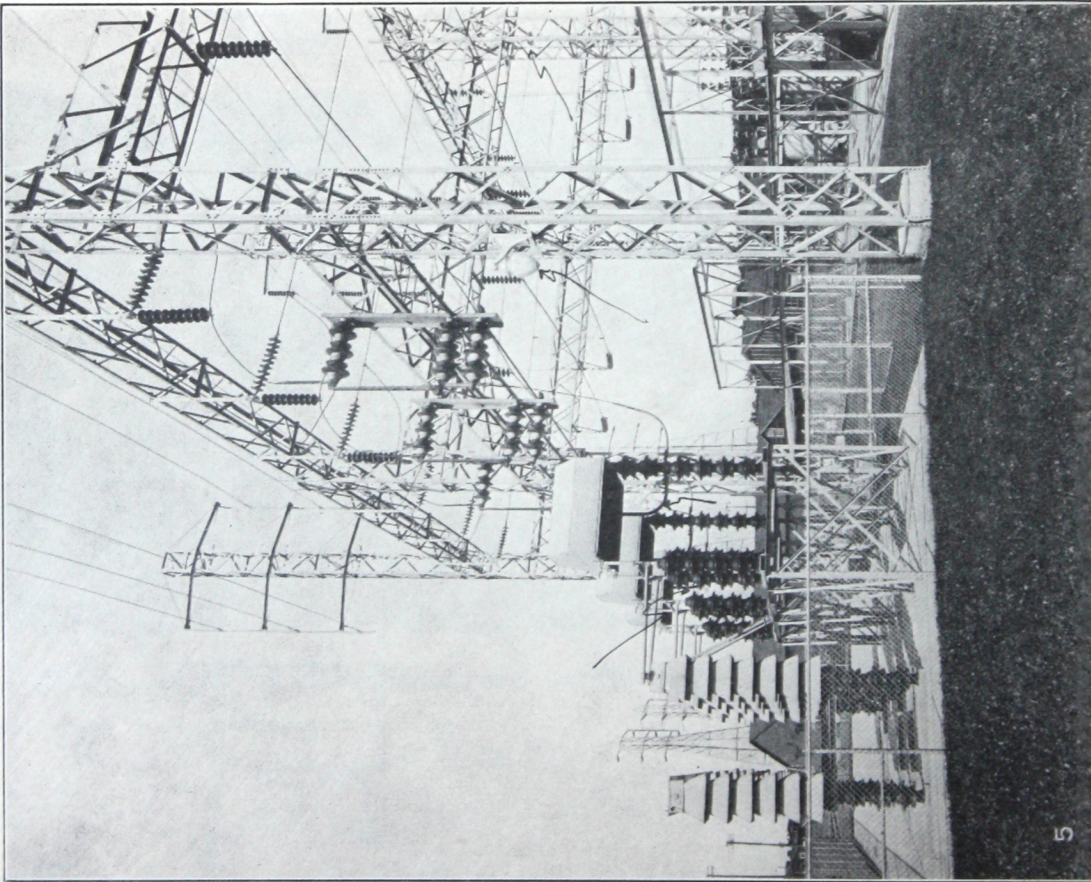
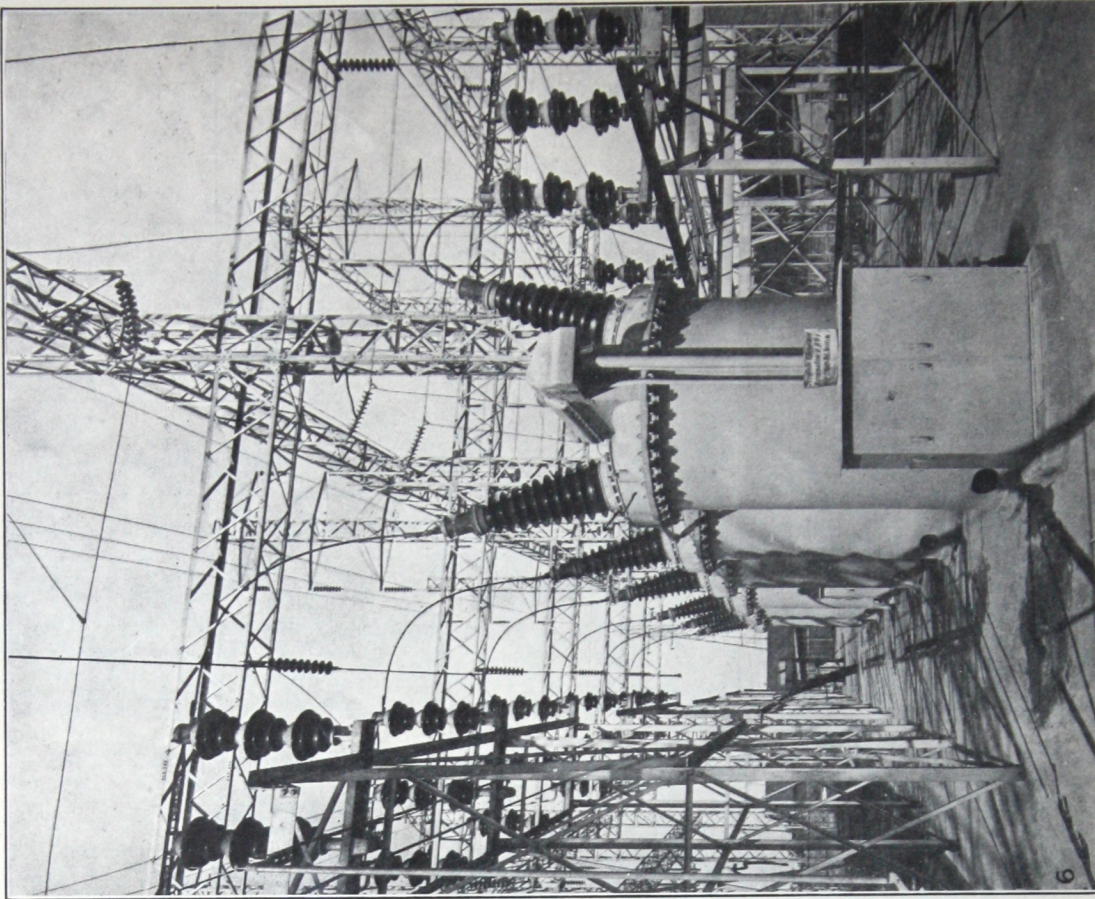


Fig. 3—Night View, 12 Kv Switchyard—Central Arizona Light and Power Company





Figs. 5 and 6—Day Views, Trenton Channel 120 Kv Switching Station—The Detroit Edison Company

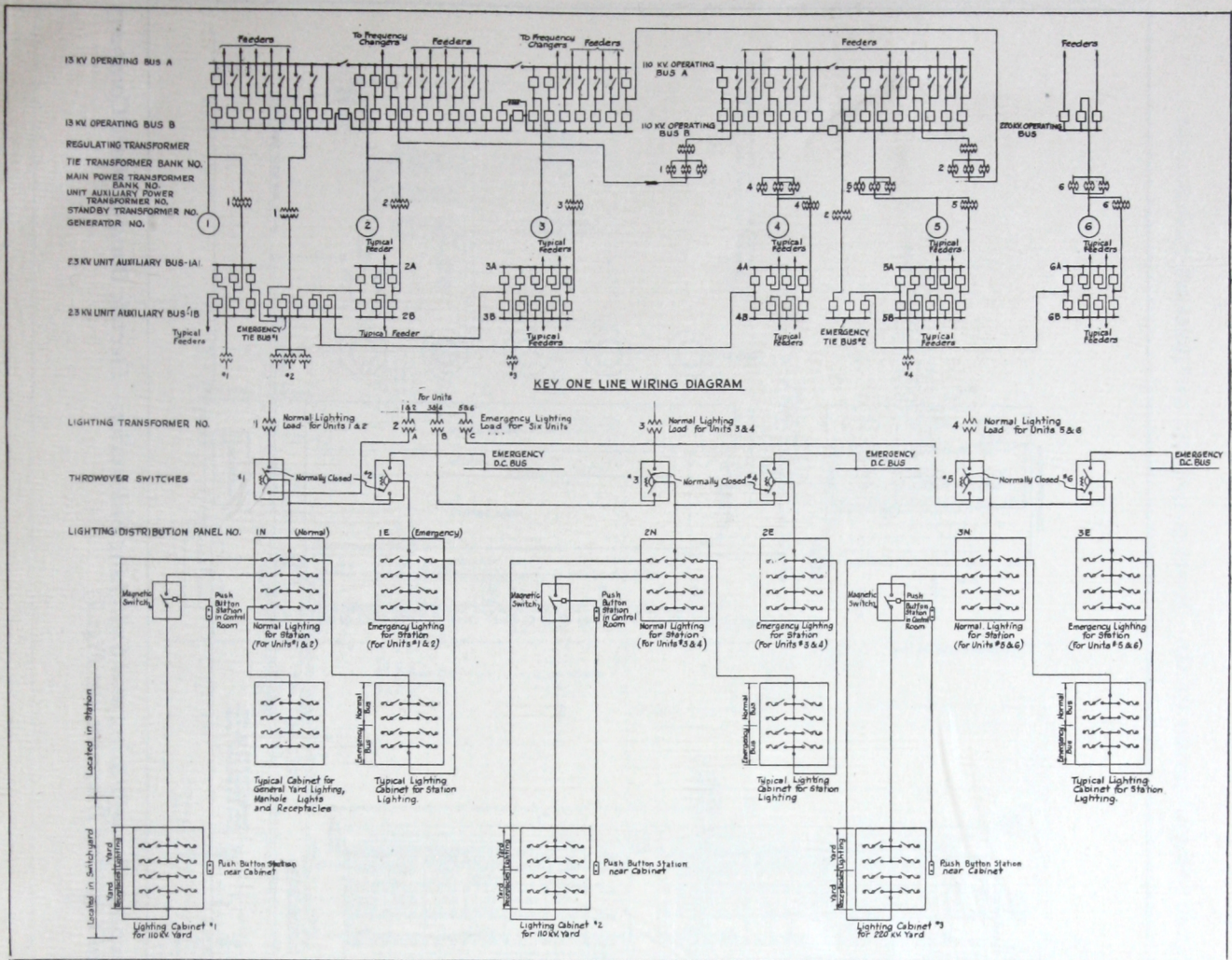


Fig. 7—(Above)
Typical Key One
Line Lighting
Diagram for a
Large Step-up
Transforming
and Switching
Substation—
Electric Bond and
Share Company

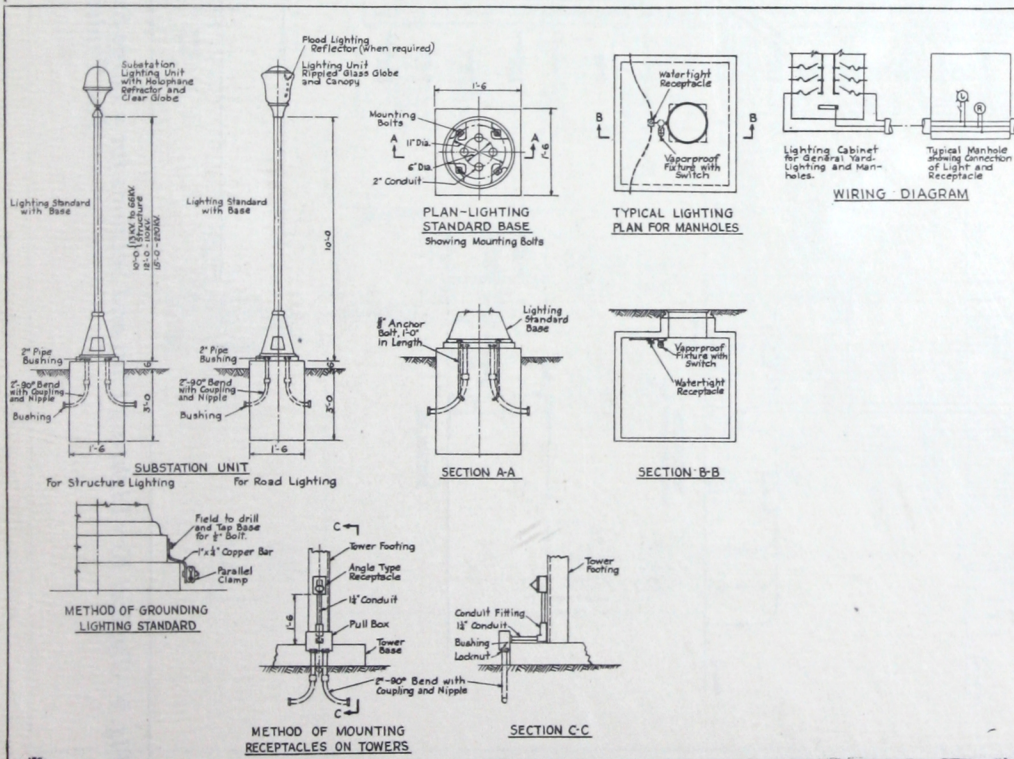


Fig. 8—(Left)
Typical Lighting
Details for Out-
door Substations
—Electric Bond
and Share Com-
pany

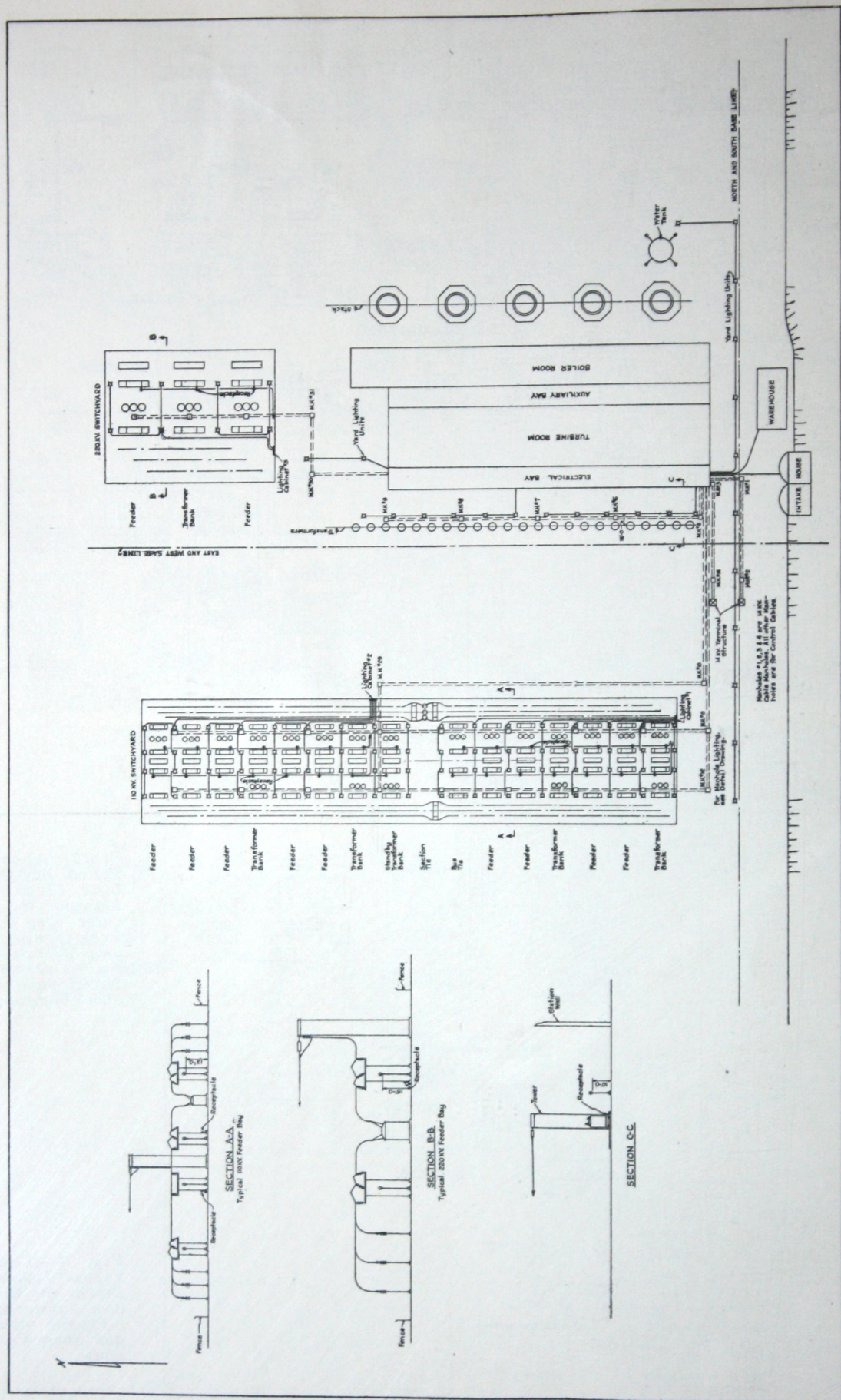


Fig. 9—Typical Key Lighting Plan and Sections for a Large Step-up Transforming and Switching Substation—Electric Bond & Share Company
(For Typical Lighting Diagram see Fig. 7)

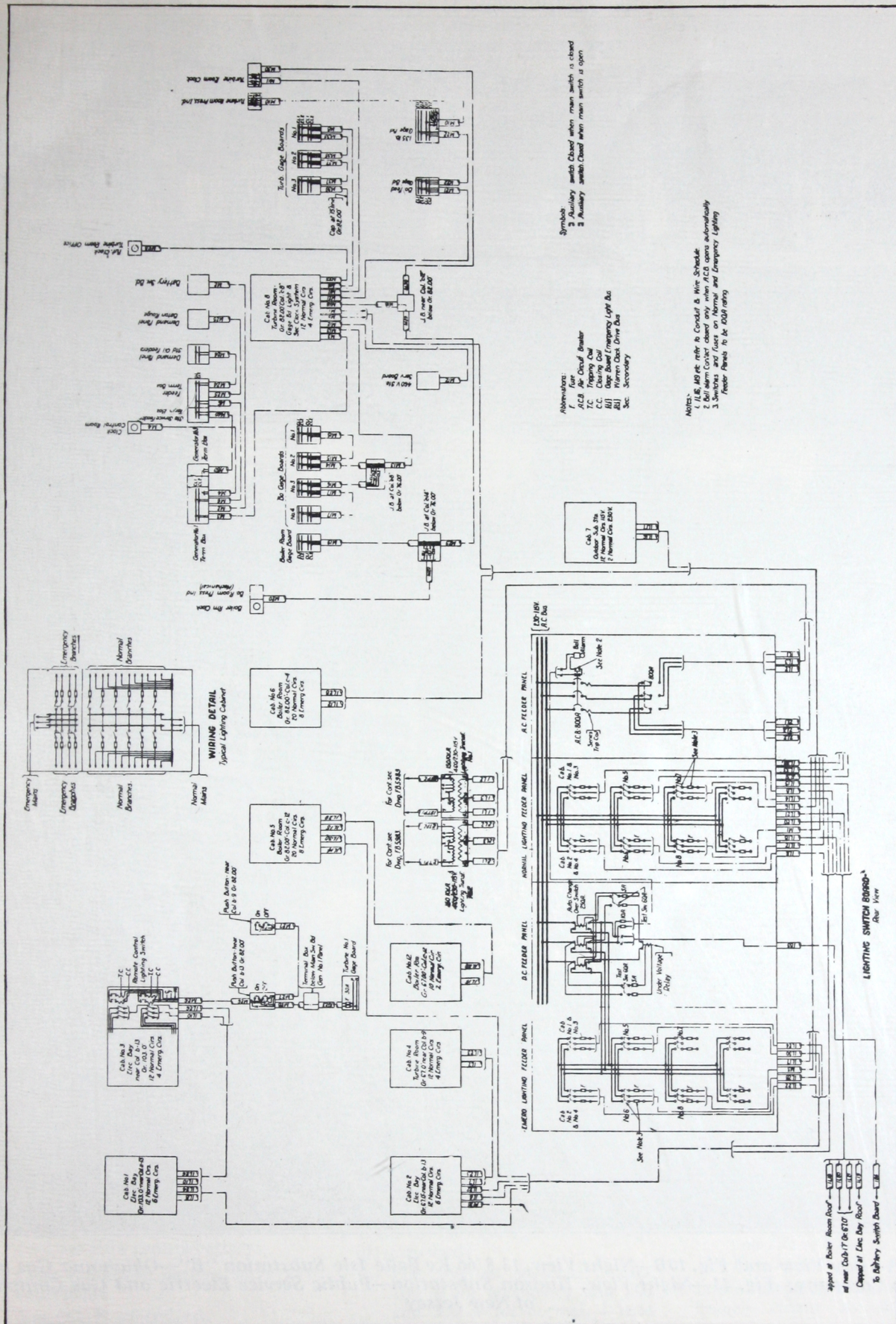


Fig. 10—Wiring Diagram, Station Lighting, Louisiana Station, Baton Rouge—Stone & Webster Engineering Corporation

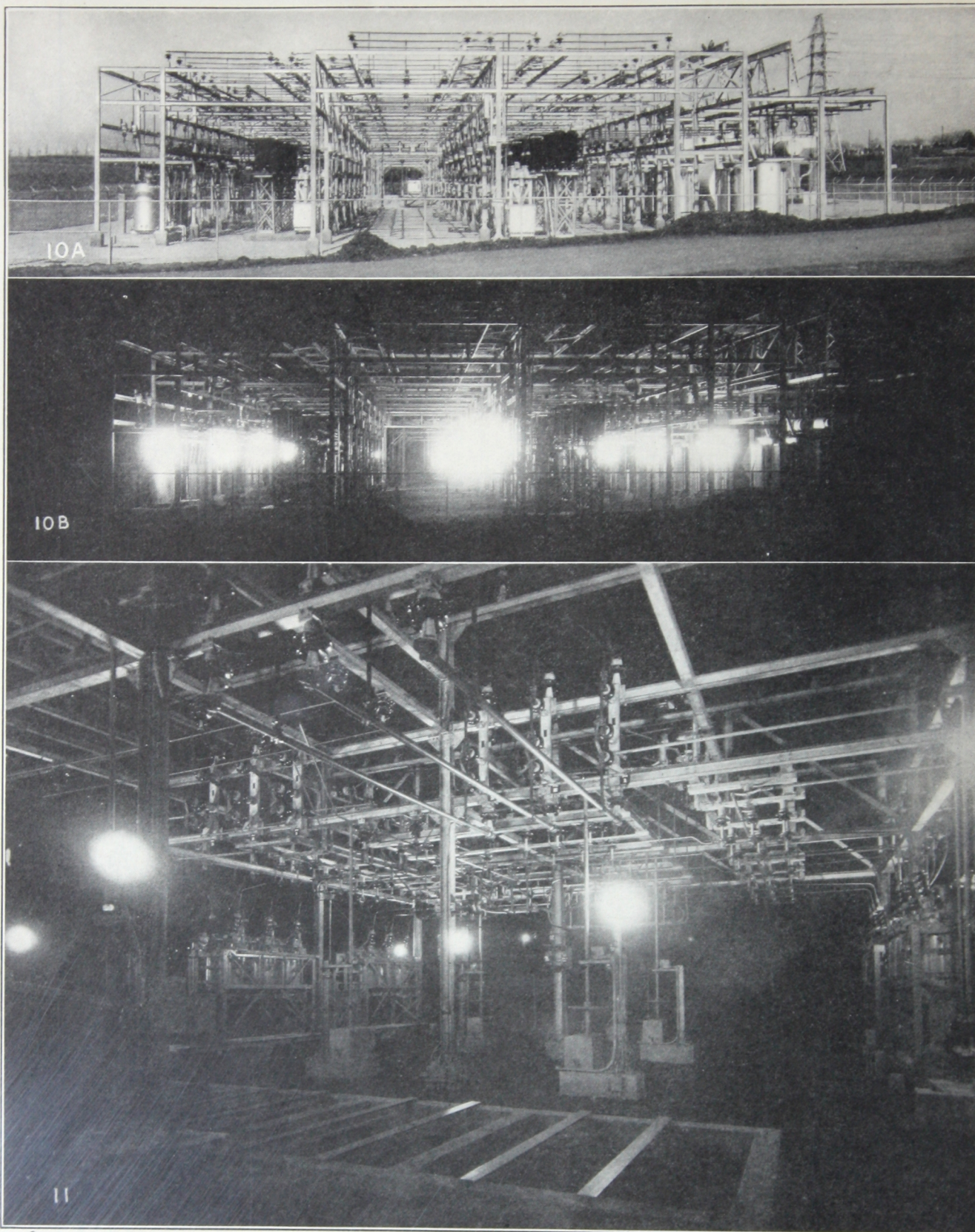


Fig. 10A—Day View and Fig. 10B—Night View, 13.8/66 Kv Belle Isle Substation "B"—Oklahoma Gas and Electric Company; Fig. 11—Night View, Hudson Substation—Public Service Electric and Gas Company of New Jersey

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CLASS II

A Large Transforming and Switching Substation Located on the Transmission System, Remote from a Generating Station.

General

- 1 What is the substation nominal voltage?
1—13.2 kv 7—66 kv 5—132 kv
1—33 kv 2—110 kv 1—165 kv
- 2 What is the type of substation structure (wood, steel, "Flat" or "Truss," etc.)?
All use steel structures.
15—"Truss" type, 2 "Flat" type.

Lighting Supply Equipment

- 1 Is the lighting wiring system 2 or 3 wire?
10—Use 3 wire.
7—Use 2 wire.
- 2 Is the normal lighting circuit or circuits alternating or direct current and what is the voltage?
All use alternating current.
2—110 v, 2 wire.
2—110/220 v, 3 wire.
1—115 v, 2 wire.
8—115/230 v, 3 wire.
4—120/240 v, 3 wire.
- 3 Is the emergency lighting circuit the same as the normal circuit with a separate emergency source of power alternating or direct current, or is the emergency lighting circuit an entirely separate circuit, alternating or direct current?
8—Use separate emergency circuits and direct current emergency source.
7—Use no emergency lighting.
2—Use same circuits and separate alternating current emergency source.
- 4 How are the transformers connected? (Open or closed delta, 3 wire, etc.)?
7—Use single phase, 3 wire.
5—Use closed delta.
2—Use open delta.
1—Uses single phase, 2 wire.
- 5 Do the above transformers serve any load other than lighting?
11—Use the transformers for light and power.
4—Use the transformers for lighting only.
- 6 What is the voltage of battery used for normal or emergency lighting?
7—Use 125 v control battery.
1—Uses 250 v control battery.
- 7 Does the above battery serve any other load?
Yes, O.C.B. control, etc.

8 What type of outdoor lighting control cabinets are used?

8—Use indoor type cabinets located in control house.

5—Use outdoor type cabinets, of which (1) has remote controlled contactor in the main feed to the cabinet. The contactor is controlled from a push button station located in the control room.

1—Uses indoor type cabinet located in the control room and furnished with remote controlled contactor for main feed. The push button station is located outdoors at the structure.

1—Uses outdoor safety switches instead of cabinets.

Lighting Units

1 Is floodlighting, or overhead or inverted lighting system used?

9—Use inverted.

4—Use floodlighting.

2—Use inverted and overhead combined.

2—Use inverted and floodlighting combined.

2 How many units are normally lighted?

12—All units lighted.

5—No units lighted (inspection only).

1—Part of the units lighted.

3 What is the approximate time when the lights are turned on and off?

11—Have all lights on all night.

5—Have lights on only during switching or inspection.

1—Has all lights on until midnight.

4 Are the lights turned on and off automatically or manually?

14—Turn the lights on manually.

3—Turn the lights on automatically.

5 What is the type and location of the lighting control switch?

11—Use lighting cabinets or lighting panels.

3—Use time switches.

2—Use push button stations for remote controlled contactors.

1—Uses outdoor safety switches.

6 Are the units mounted on the substation structure by brackets or on separate posts or in some other manner?

9—Use brackets.

6—Use posts.

2—Use brackets and posts.

7 What is the wattage and voltage of lamps used?

(a) For inverted systems, 1 uses 100 w for emergency and 200 and 300 w for normal, 1 uses

200 w, 1 uses 200 w for emergency and 500 w for normal, 2 use 300 w, 2 use 300 w for emergency and 500 w for normal and 2 use 500 w lamps.

(b) For inverted and overhead systems, 2 use 100 w and 300 w lamps, the 100 w lamps are used for emergency only.

(c) For inverted and floodlighting systems, 1 uses 200, 500 and 1,000 w for inverted and 500 w for floodlights, 1 uses 200 w auxiliary and 750 or 1,000 w flood lamps.

(d) For floodlighting systems, 1 uses 250 w, 2 use 500 w and 1 uses 1,000 w lamps.

13—Use same voltage lamps as their transformer secondary.

2—Use 120 v lamps on 115 v circuits.

1—Uses 120 v lamps on 110 v circuits.

1—Uses 130 v lamps on 120 v circuits.

8 What is the mounting height above grade?

Average approx. 15 ft for brackets and 11 ft for posts.

9 What is the approximate lighting intensity in foot candles on the major electrical equipment (on vertical plane)?

10—Use from 1 to 5 fc.

2—Use from 5 to 10 fc.

10 What is the approximate lighting intensity in foot candles on the ground (on horizontal plane)?

10—Use from 0.1 to 2 fc.

3—Use from 2 to 5 fc.

Substation Receptacle Outlets

1 Do you provide receptacles in the substation for hand lamps or small portable motors?

15—Provide receptacles.

2—Do not provide receptacles.

2 Are the receptacles mounted on the substation structure, or on lighting posts or in some other manner?

13—Mount receptacles on the structures.

2—Mount receptacles on the lighting posts.

3 What is the average spacing of receptacles?

Approximately 40 ft.

4 Is the receptacle wiring system single or 3 phase and what voltage?

12—Use single phase, 115 v.

2—Use both single phase, 115 v and 230 v, 3 phase.

1—Uses 3 phase, 115 v.

5 Is the receptacle fed from the same branch circuit as the adjacent

lighting units or is it connected to a separate circuit?

11—Use separate circuits.

4—Use the same circuit as lighting.

Manhole Lighting and Outlets

1 Do you install permanent lighting in your power and control cable manholes?

All have no permanent lighting.

Lighting Cables

1 What is the cable size, type, insulation and covering used for feeding the lighting units and receptacles?

9—Use No. 6, 8, 10 or 12 rubber covered, lead covered cable.

6—Use No. 4, 6, 10 or 14 rubber covered, lead covered, "Parkway" cable.

2—Use No. 10 or 14 rubber covered, braided cable.

2 Are the lighting cables installed in fiber or iron ducts, armored cable laid directly in ground or installed in some other manner?

Lead covered cable is installed in fiber and iron ducts. "Parkway" cable is laid directly in the ground. Rubber covered, braided cable is installed in exposed conduits and lighting posts and brackets.

3 How is the cable protected if laid directly in the ground?

4—Use no covering over "Parkway" cable.

2—Use creosoted wooden planks over "Parkway" cable.

4 Is braided or lead covered cable used from the ground to the lighting unit?

12—Use braided cable.

3—Use lead covered cable.

5 How are the lighting fixtures grounded?

15—Use no special grounding but mount fixtures on grounded steel structures or connect them to conduit system.

2—Connect the lighting post bases to the station grounding system.

6 What provisions are made for grounding portable hand lamps, etc.?

16—Make no provision.

1—Uses a separate No. 8 all-rubber insulated wire permanently attached to appliance. A test clip on the other end of the wire is clamped to the nearest ground.

The following eighteen (18) companies contributed data on illumination design for outdoor substations in Class II, a large transforming and switching substation, located on the transmission system remote from a generating station.

Cleveland Electric Illuminating Company

Consumers Power Company

The Detroit Edison Company

Georgia Power Company

Gulf States Utility Company

Hamilton Service Company

Houston Lighting and Power Company

Kansas Gas and Electric Company

The Milwaukee Electric Railway and Light Company

Ohio Power Company

Oklahoma Gas and Electric Company

Pennsylvania Power and Light Company

Philadelphia Electric Company

Public Service Company of Colorado

Public Service Company of Northern Illinois

Shawinigan Water and Power Company

United Electric Light Company

Washington Water Power Company

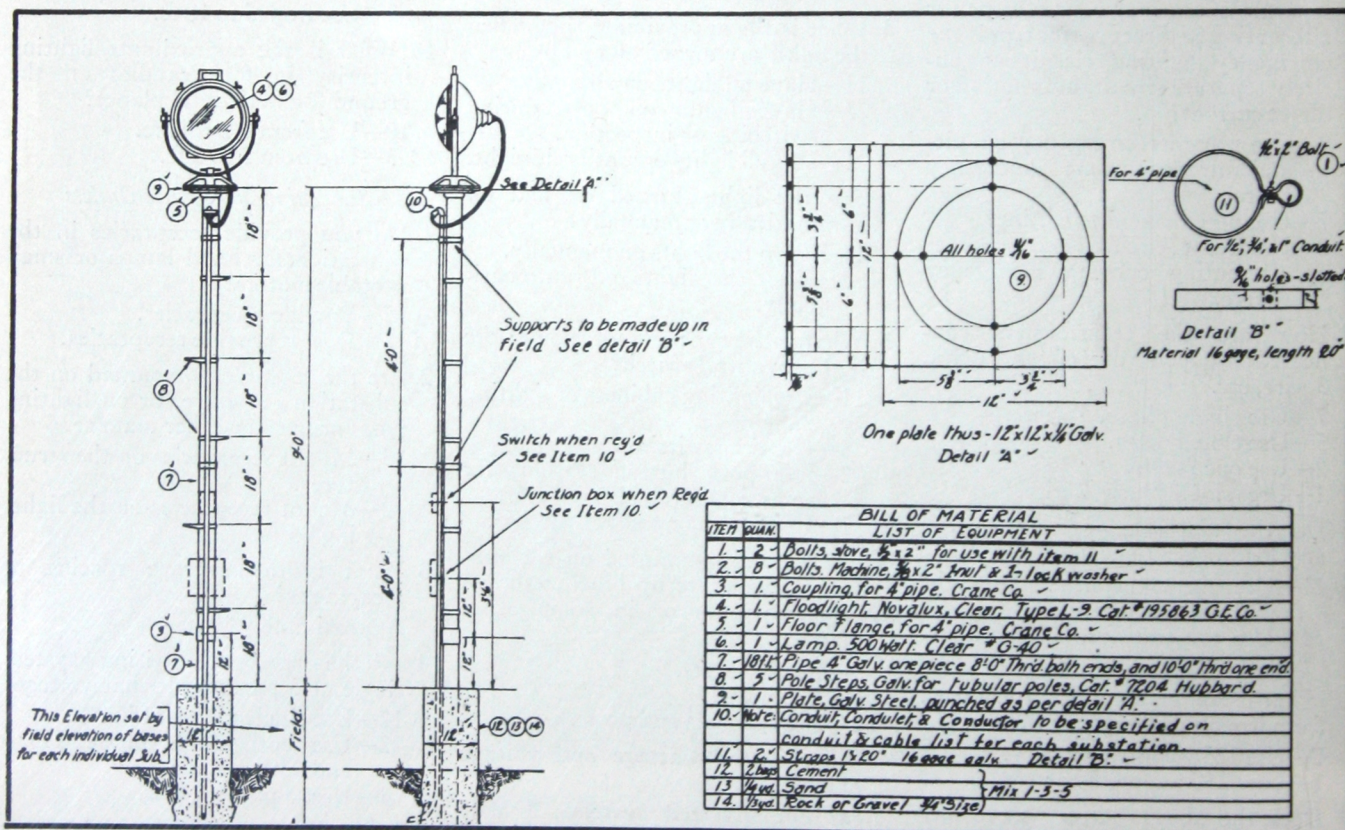
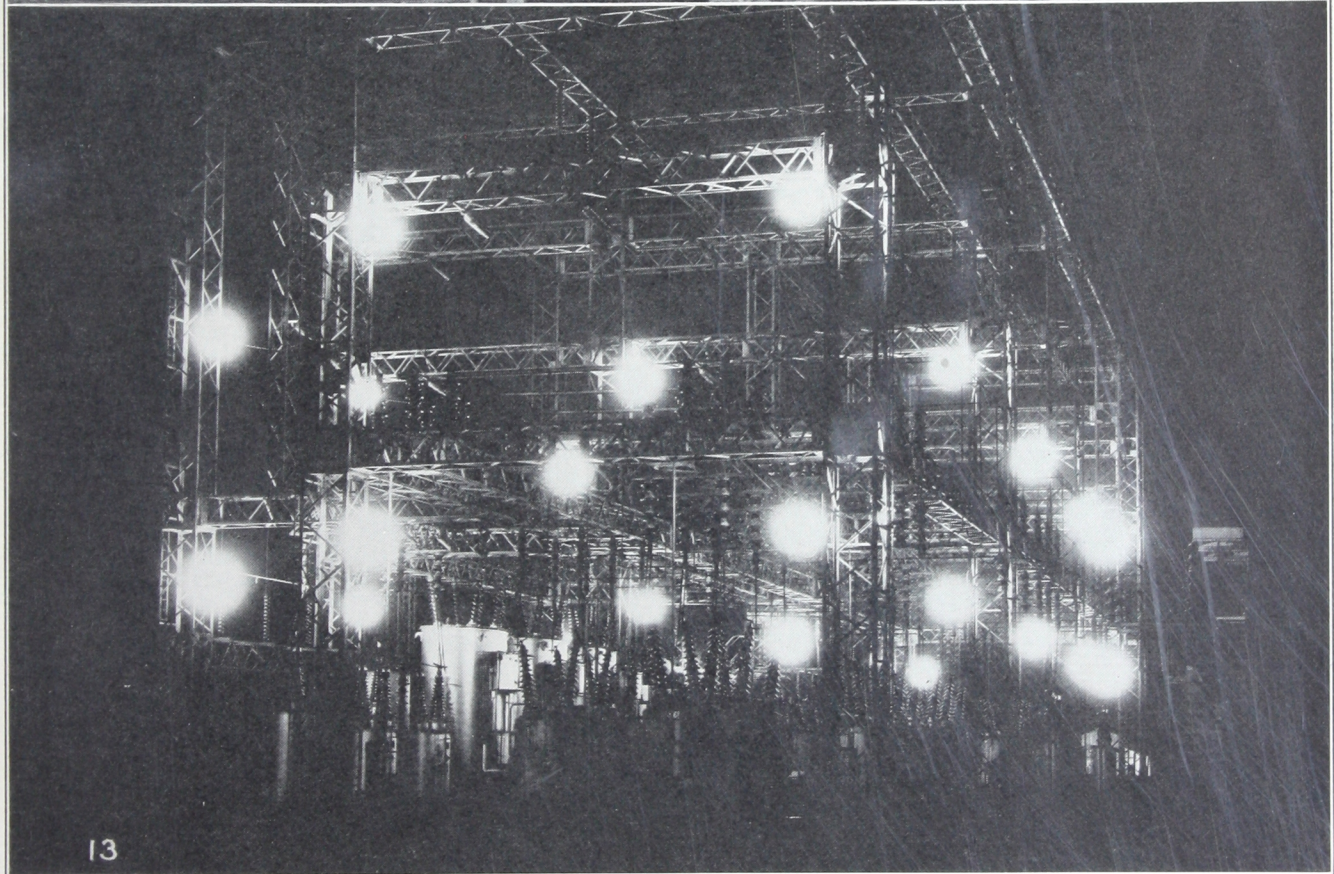
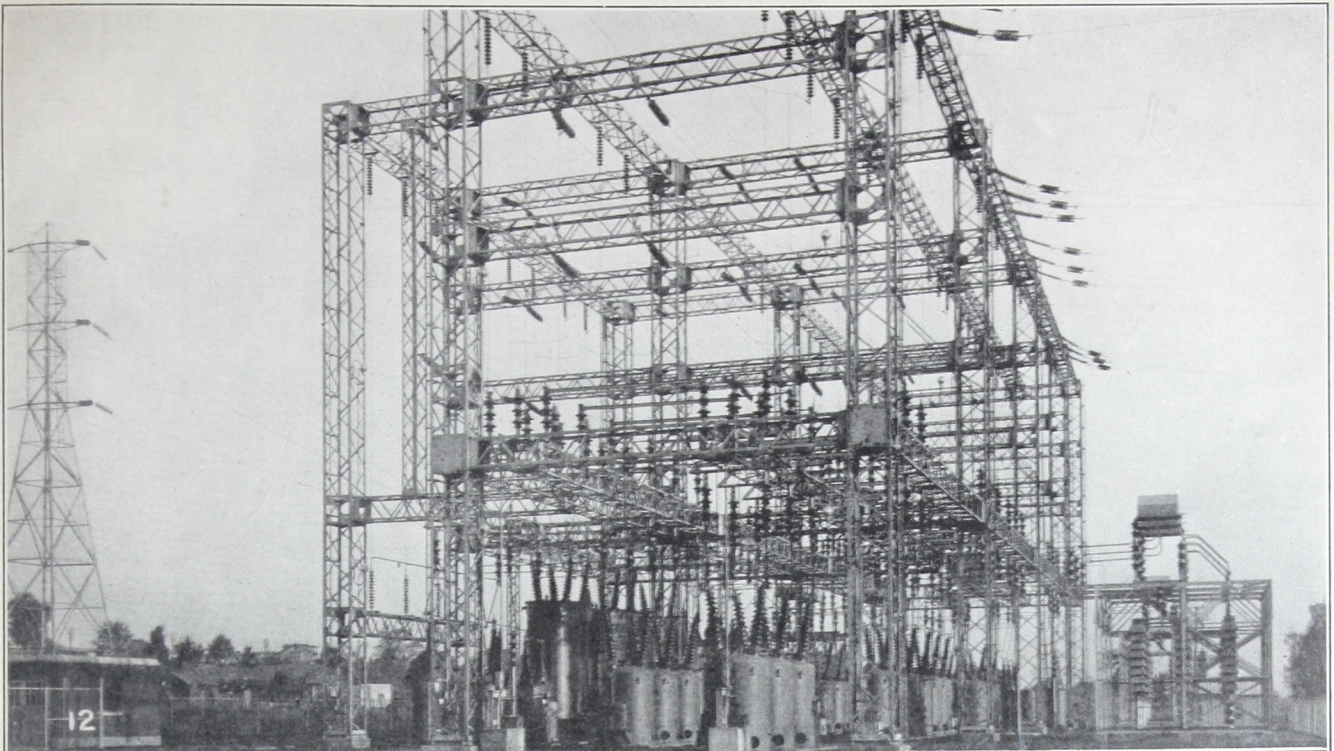
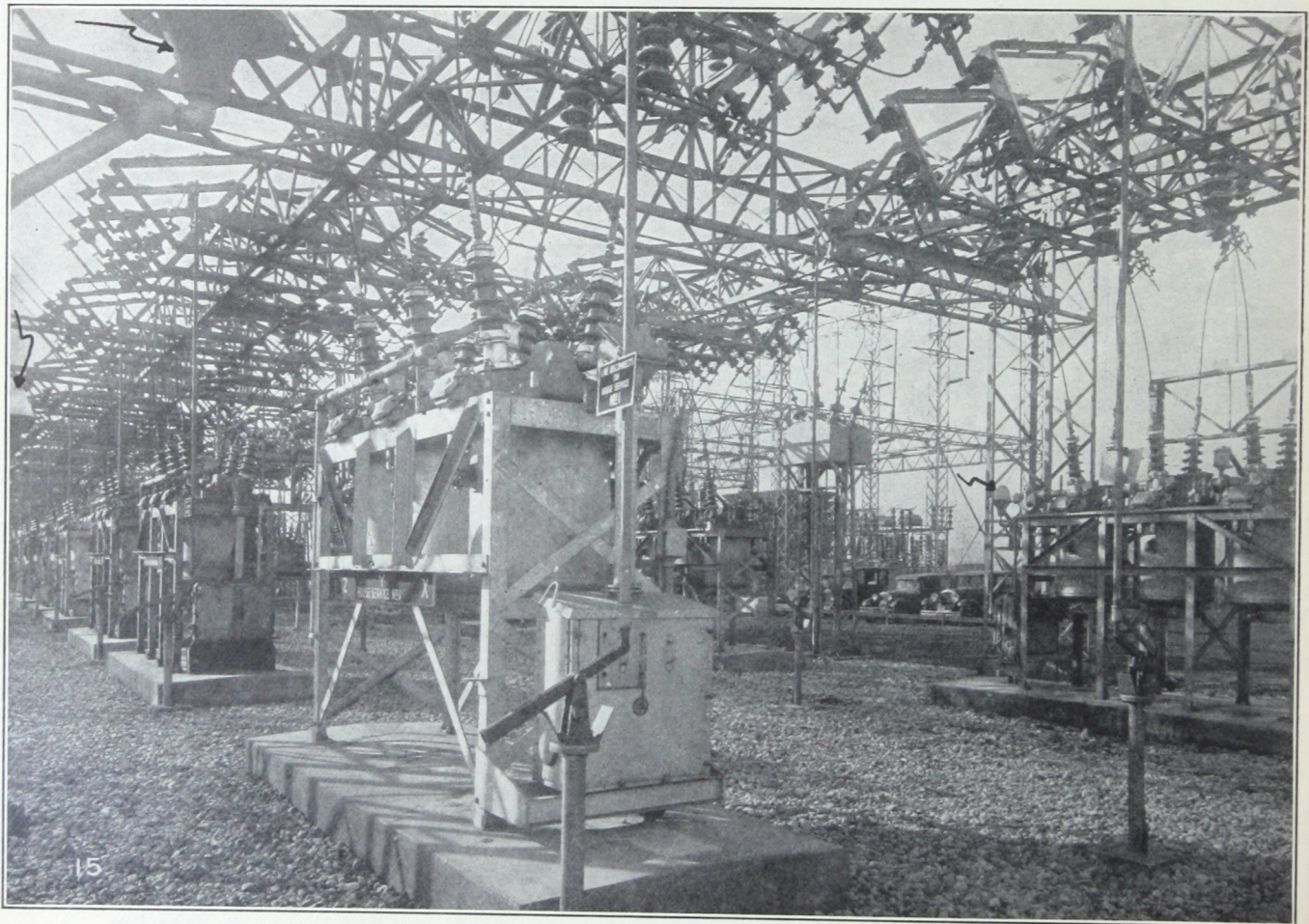
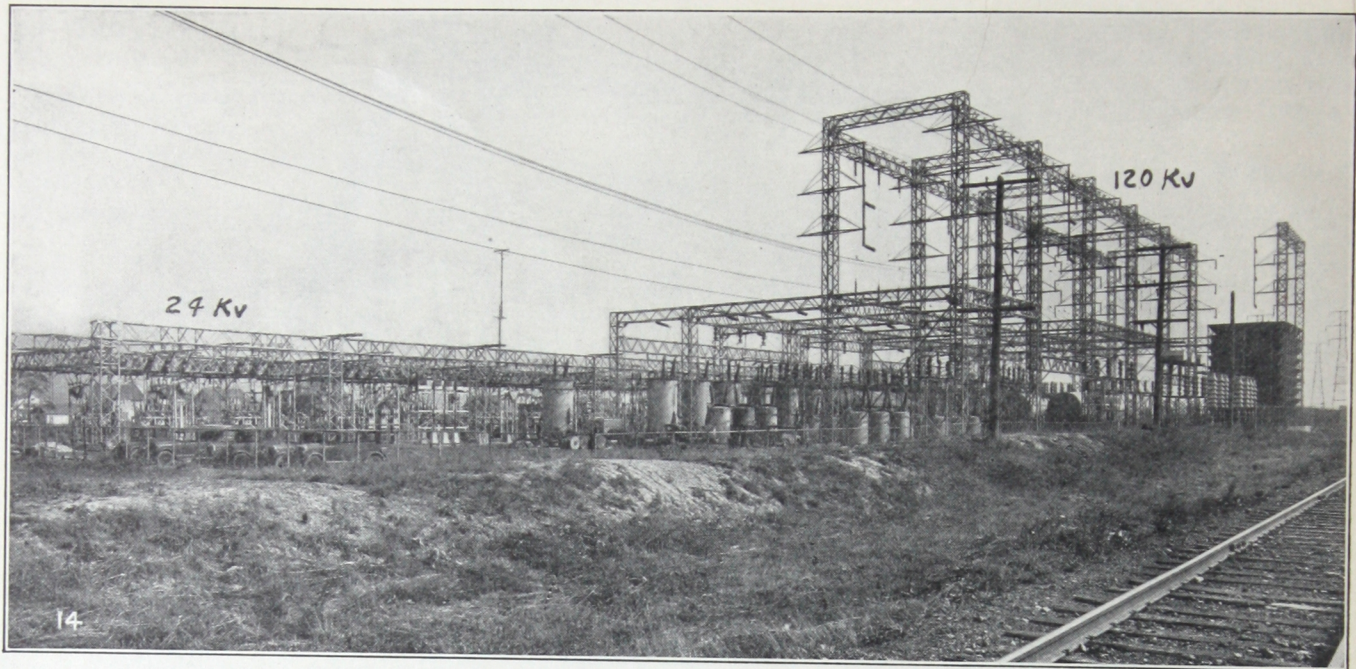


Fig. 11a—Standard Substation Floodlight Unit—Kansas Gas and Electric Company



*Fig. 12—Day View and Fig. 13—Night View, 140 Kv Structure Blackstone Substation
Consumers Power Company*



Figs. 14 and 15—Views of the 24 Kv and 120 Kv Warren Substation—The Detroit Edison Company

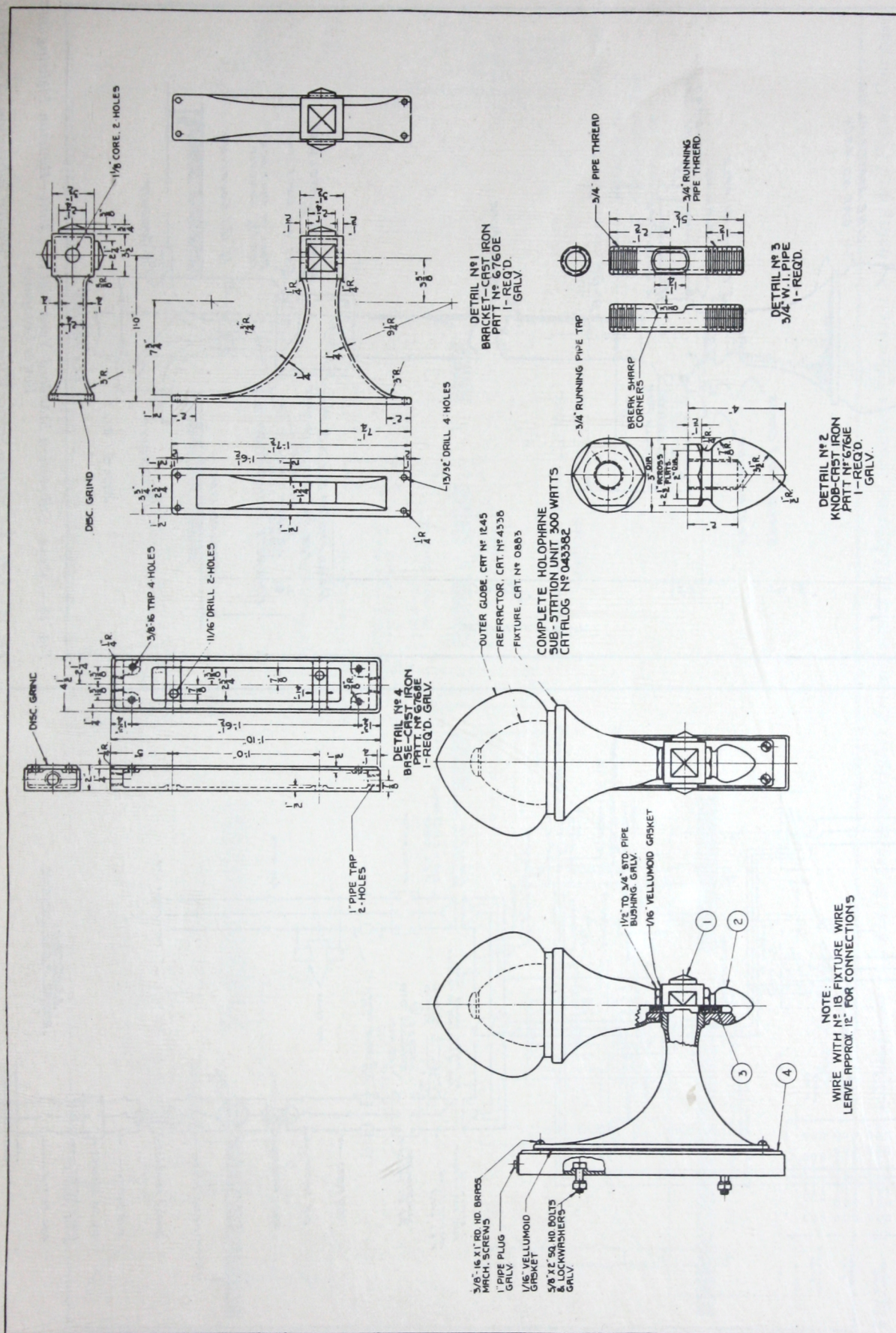


Fig. 16—Steel Tower Exterior Lighting Fixture—The Detroit Edison Company

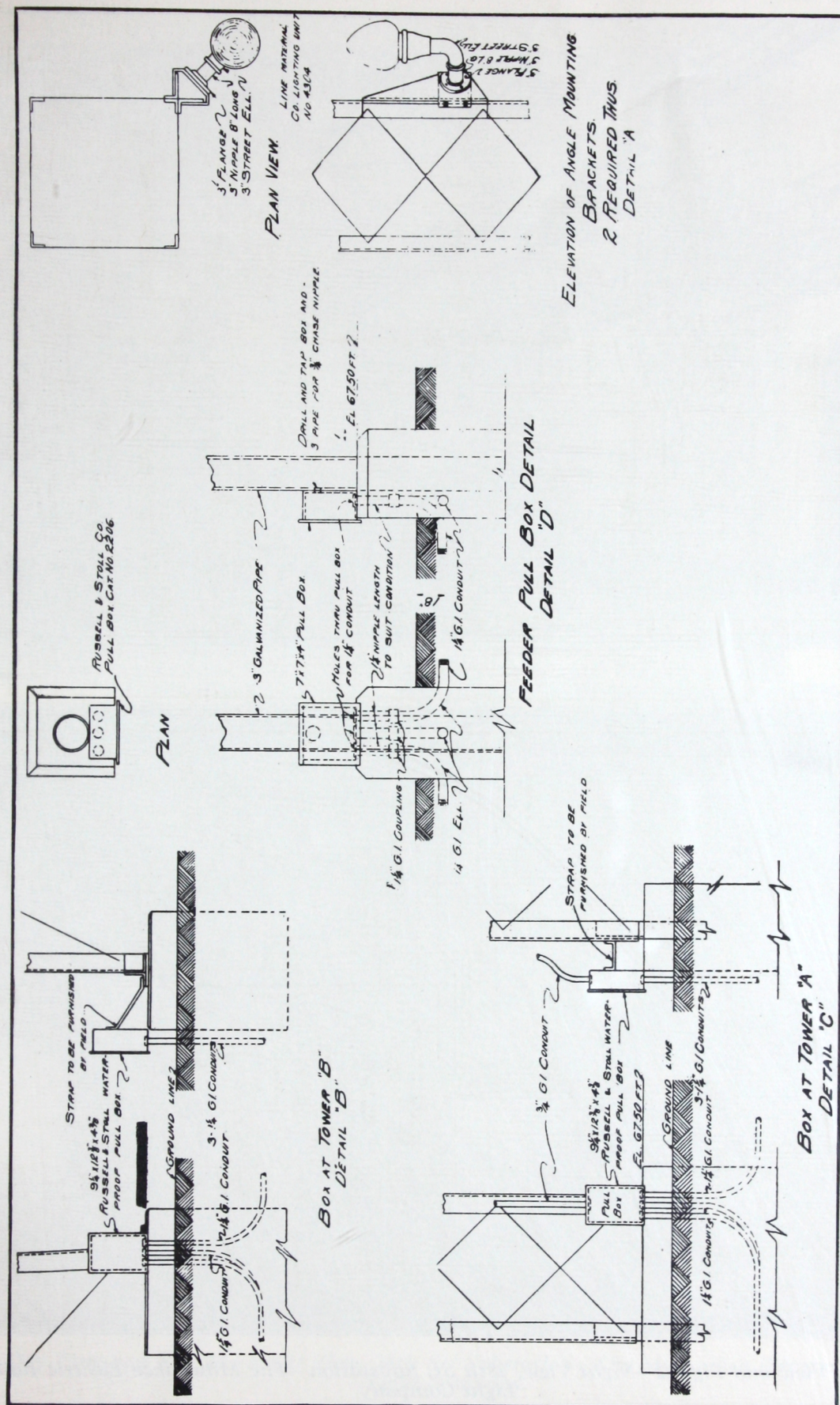


Fig. 19—Arrangement of Pull Boxes and Fig. 20 (extreme right) Arrangement of Lighting Brackets—Houston Lighting and Power Company

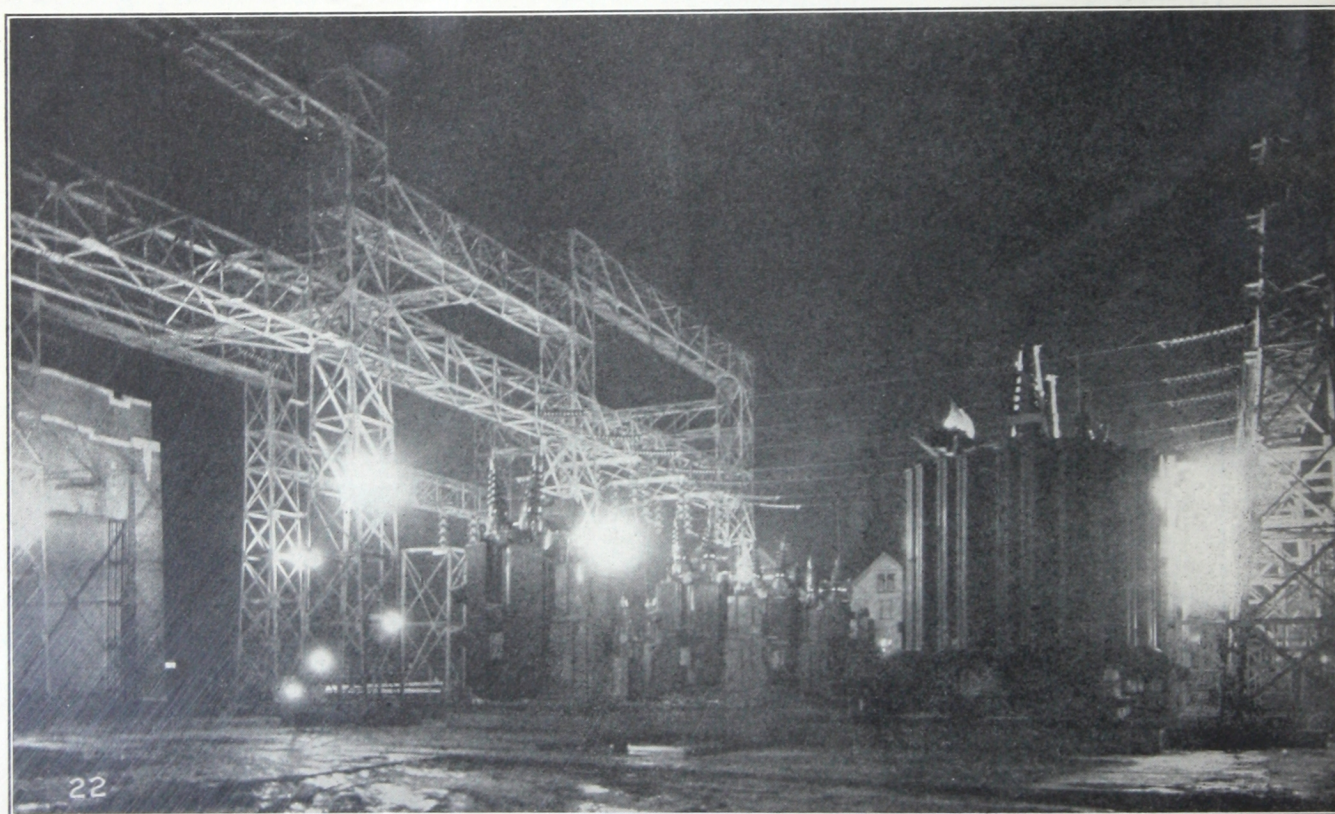
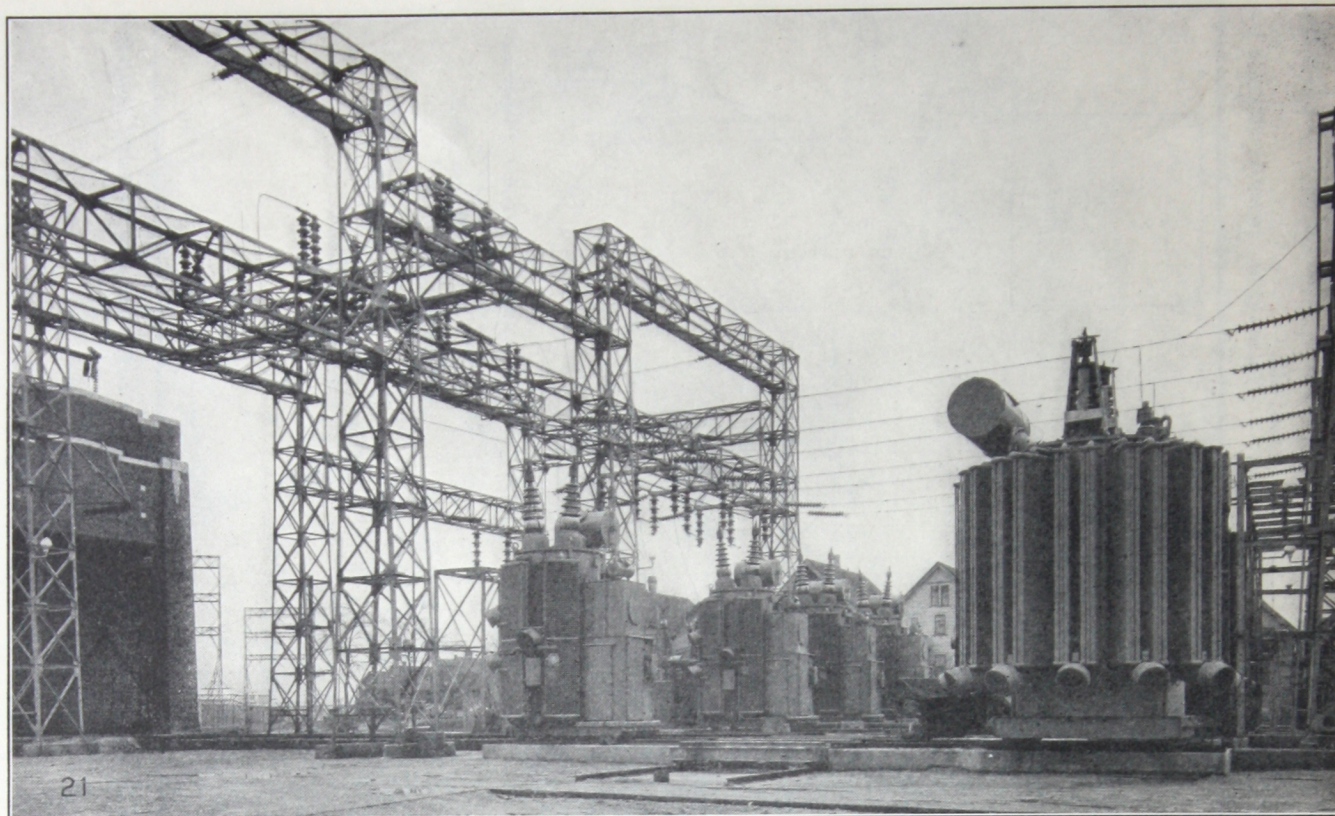


Fig. 21—Day View and Fig. 22—Night View, 28th St. Substation—The Milwaukee Electric Railway and Light Company

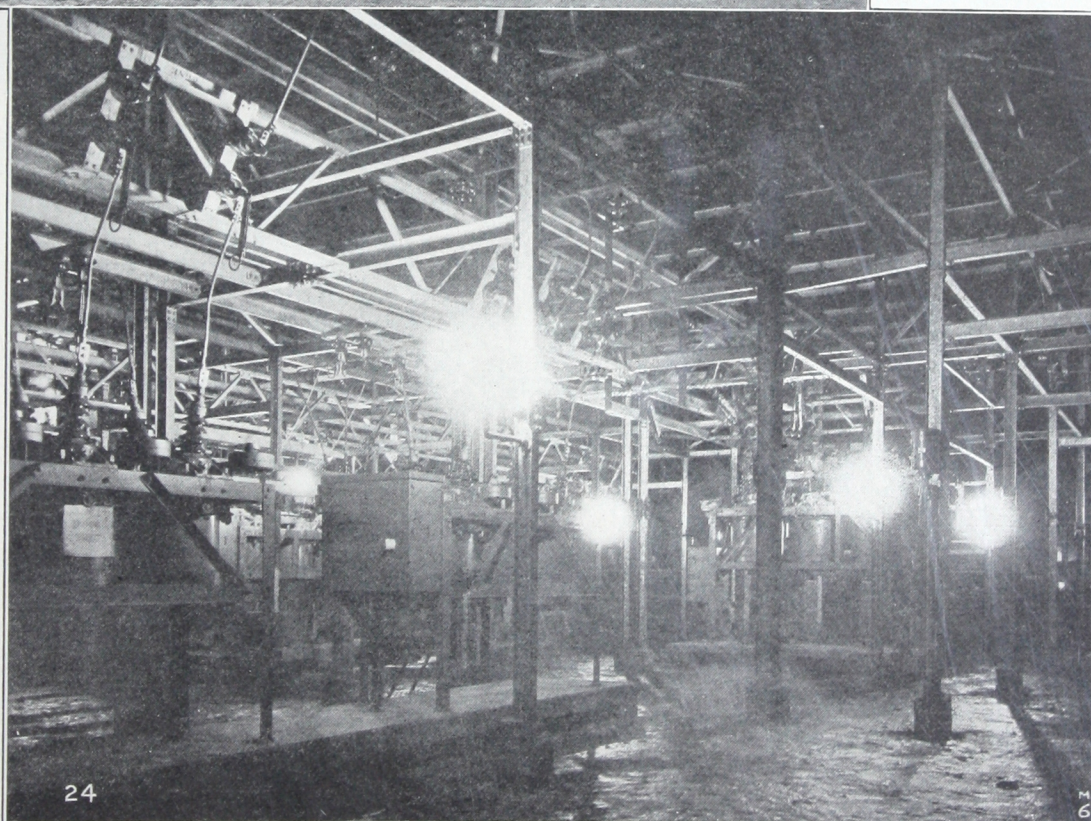
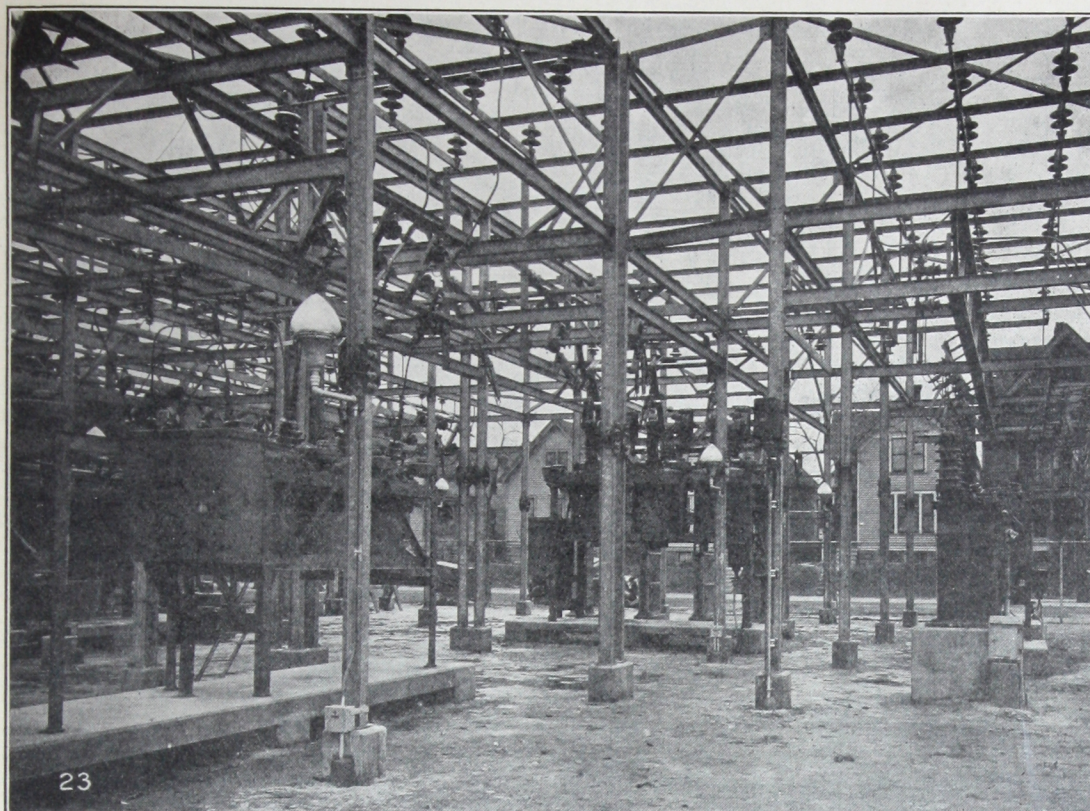
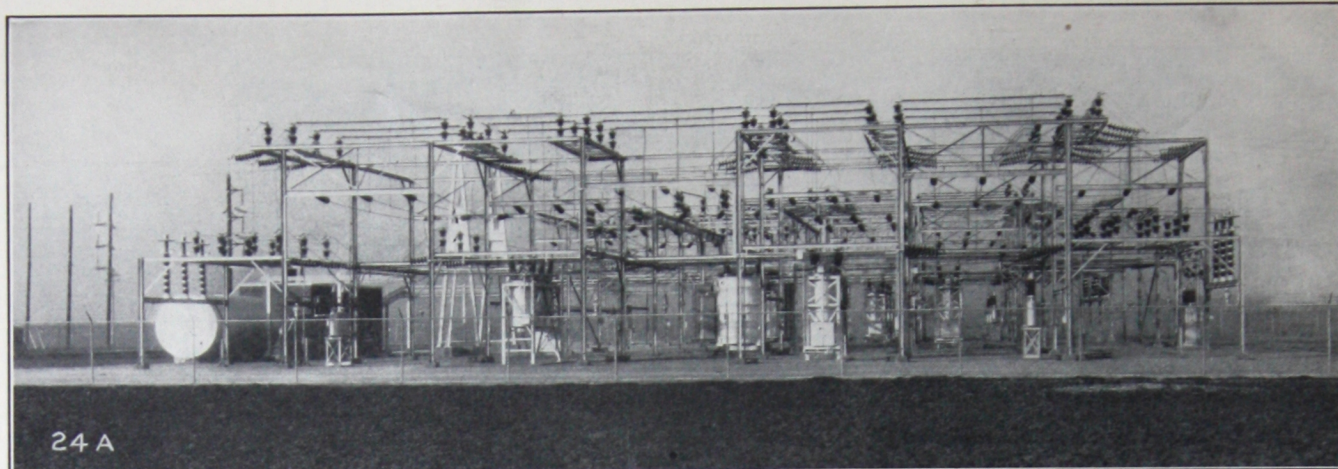
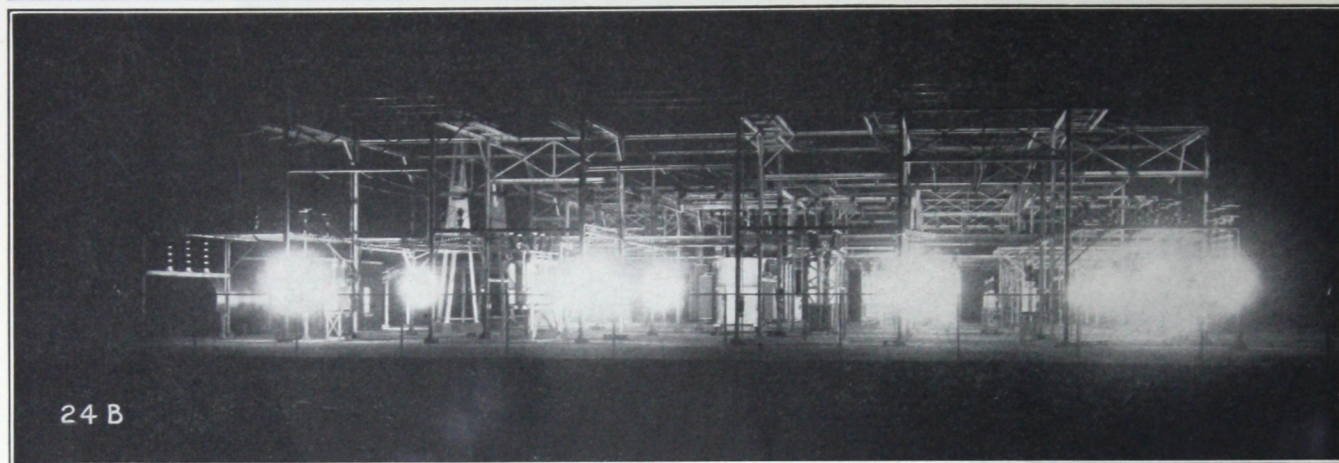


Fig. 23—Day View and Fig. 24—Night View, 28th St. Substation—The Milwaukee Electric Railway and Light Company



24 A



24 B

Fig. 24A—Day View and Fig. 24B—Night View, 66 Kv Reno St. Switching Station—Oklahoma Gas and Electric Company

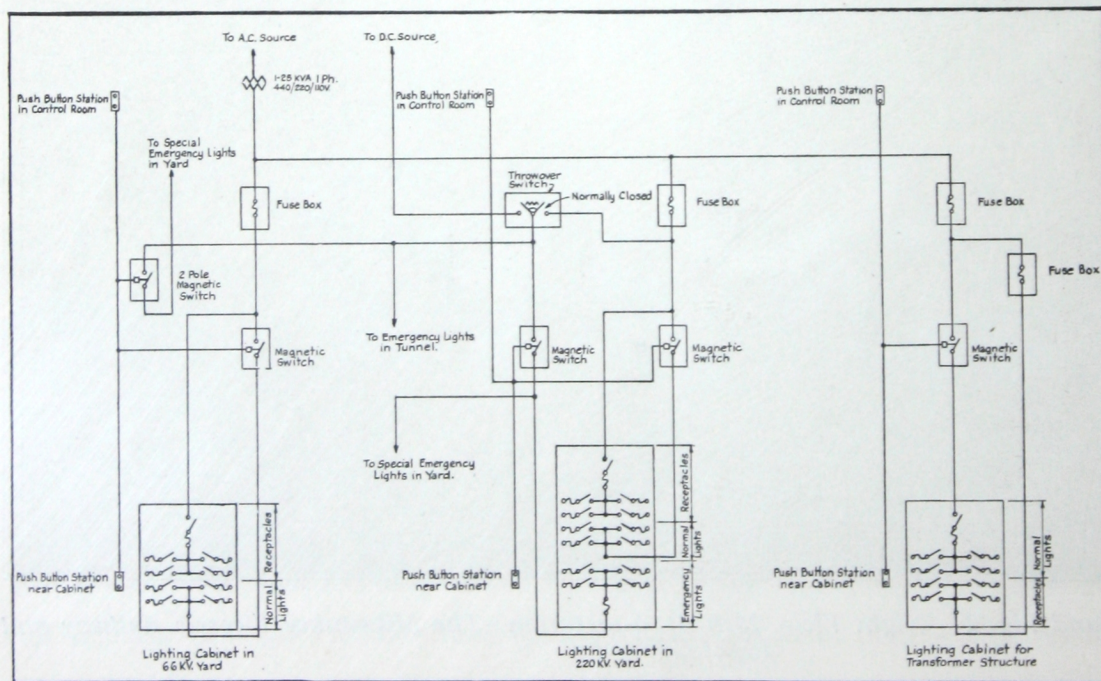


Fig. 25—Key One Line Lighting Diagram, Siegfried Substation—Pennsylvania Power and Light Company

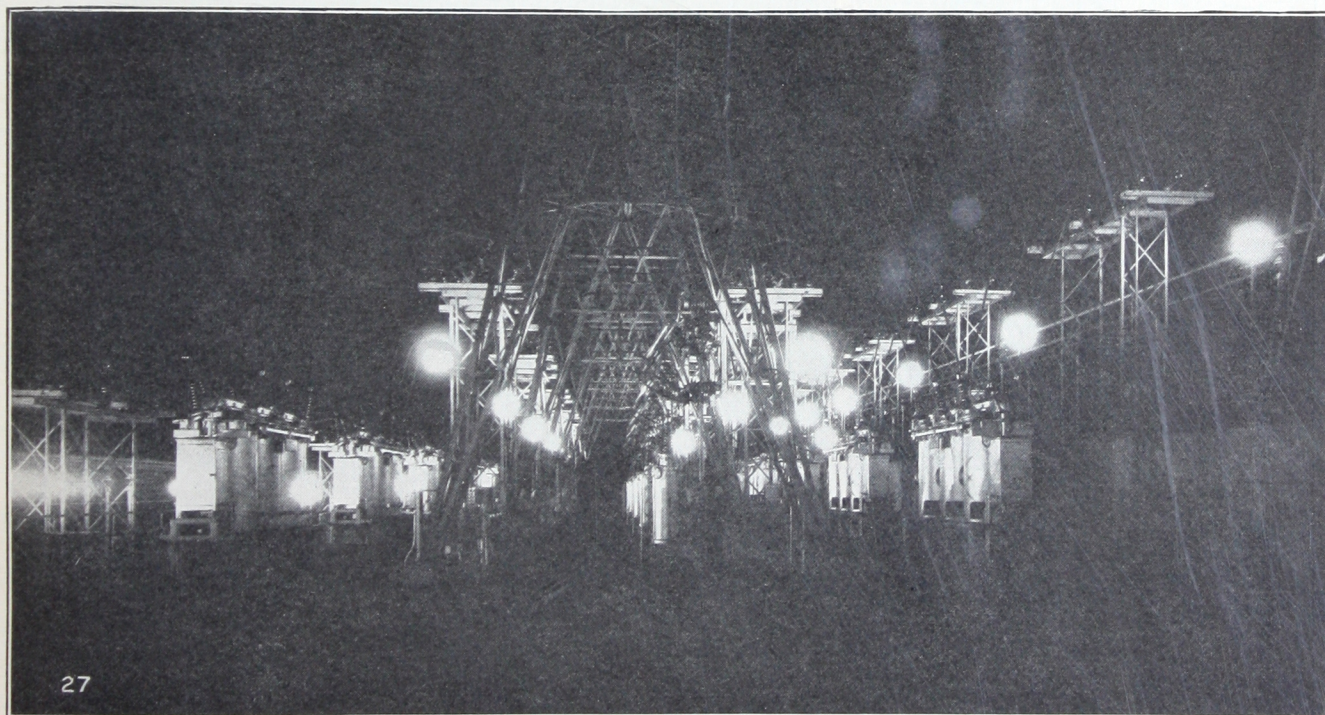
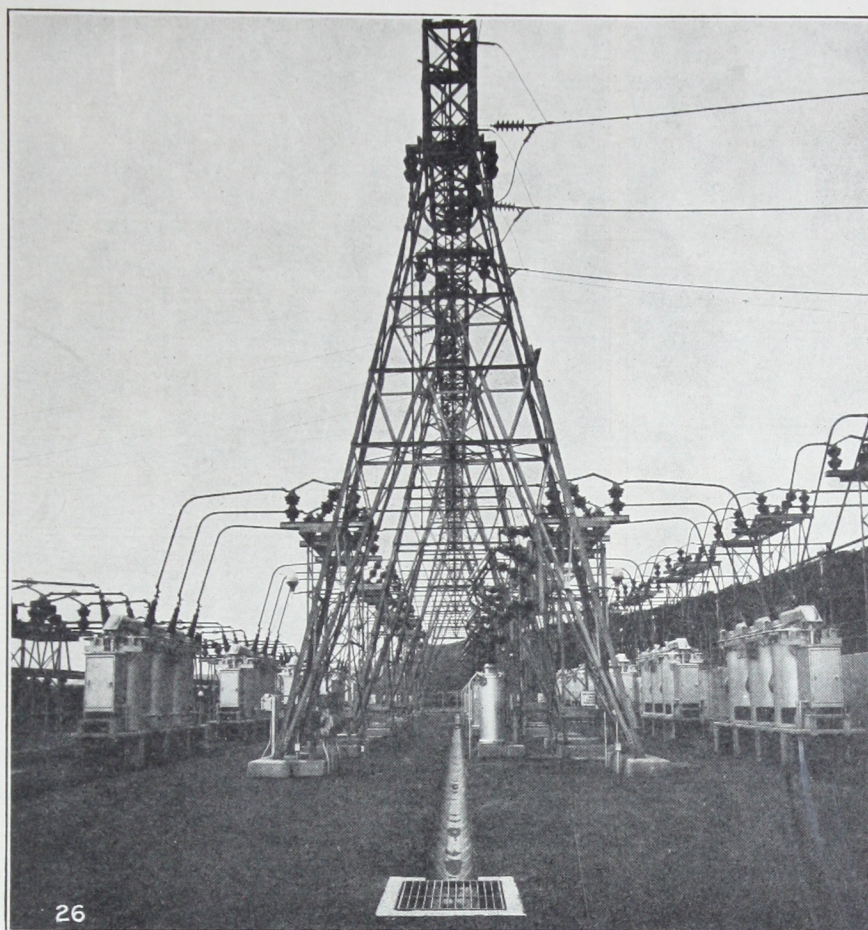


Fig. 26—Day View and Fig. 27—Night View, Siegfried 66Kv Switchyard—Pennsylvania Power and Light Company

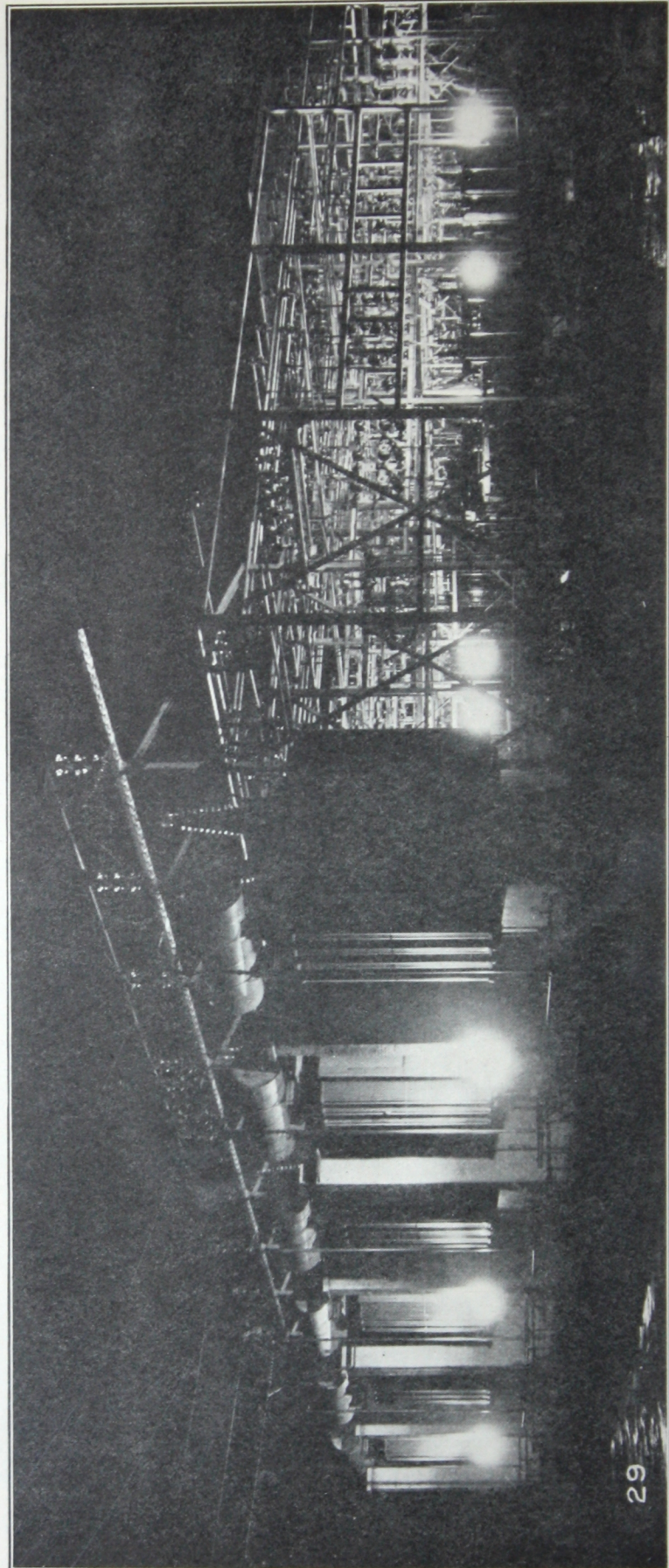
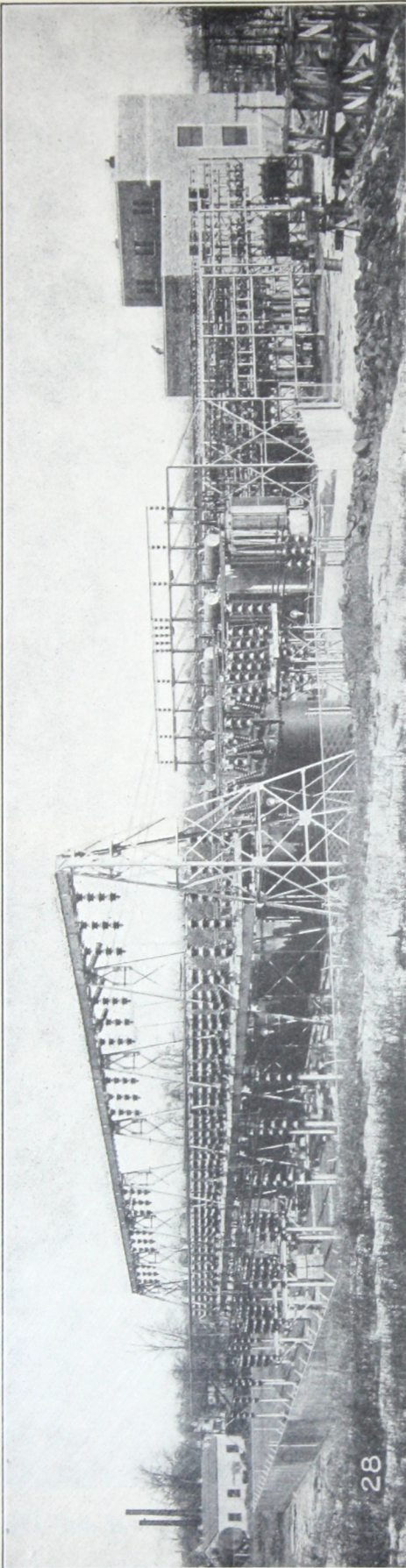


Fig 28—Day View and Fig. 29—Night View, Athenia Switching Station—Public Service Electric and Gas Company of New Jersey

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CLASS III

A Small Rural Transformer Substation.

General

- 1 What is the substation nominal voltage?
2—13.2 kv 4—33 kv 1—66 kv
3—22 kv 1—44 kv 2—110 kv
- 2 What is the type of substation structure (wood, steel, "Flat" or "Truss" etc.)?
1—Use steel structures.
2—Use pipe framework only.

Lighting Supply Equipment

- 1 Is the lighting wiring system 2 or 3 wire?
8—Use 2 wire, 3 use 3 wire.
3—Do not install any lighting equipment.
- 2 Is the normal lighting circuit or circuits alternating or direct current, and what is the voltage?
All use alternating current.
1—110/220 v, 3 wire.
1—115 v, 2 wire.
4—115/230 v, 3 wire.
5—120/240 v, 3 wire.
- 3 Is the emergency lighting circuit the same as the normal circuit with a separate emergency source of power alternating or direct current, or is the emergency lighting circuit an entirely separate circuit, alternating or direct current?
9—Use no emergency lighting.
2—Use same circuits and separate alternating current emergency source.
- 4 How are the transformers connected? (Open or closed delta, 3 wire, etc.)?
4—Use single phase, 3 wire.
3—Use open delta.
2—Use closed delta.
1—Uses Scott connected.
1—Uses single phase, 2 wire.
- 5 Do the above transformers serve any load other than lighting?
9—Use the transformers for light and power.
2—Use the transformers for light only.
- 6 What is the voltage of battery used for normal or emergency lighting?
No battery used.
- 7 Does the above battery serve any other load?
No battery used.
- 8 What type of outdoor lighting control cabinets are used?
7—Use indoor type cabinets located in control house.

1—Uses indoor safety switch in control house.

1—Uses time switch located outdoors in wooden cabinet.

Lighting Units

- 1 Is floodlighting, or overhead or inverted lighting system used?
8—Used inverted.
2—Use overhead.
1—Uses floodlighting.
- 2 How many units are normally lighted?
8—No units lighted (inspection only).
3—All units lighted.
- 3 What is the approximate time when the lights are turned on and off?
8—Have lights on only during switching or inspection.
3—Have all lights on all night.
- 4 Are the lights turned on and off automatically or manually?
9—Turn the lights on manually.
2—Turn the lights on automatically.
- 5 What is the type and location of the lighting control switch?
7—Use lighting cabinets.
2—Use time switches.
1—Uses indoor safety switch.
- 6 Are the units mounted on the substation structure by brackets, or on separate posts or in some other manner?
7—Use brackets.
4—Use posts.
- 7 What is the wattage and voltage of lamps used?
(a) For inverted system, 3 use 150 w and 5 use 300 w lamps.
(b) For overhead system, 1 uses 100 w and 1 uses 500 w lamps.
(c) For floodlighting, 1 uses 500 w lamps.
9—Use same voltage lamps as their transformer secondary voltage.
1—Uses 130 v lamps on 120 v circuits.
1—Uses 130 v lamps on 110 v circuits.
- 8 What is the mounting height above grade?
Average approx. 13 ft for brackets and 10 ft for posts.
- 9 What is the approximate lighting intensity in foot candles on the major electrical equipment (on vertical plane)?
5—Use from 0.25 to 5 fc.
- 10 What is the approximate lighting intensity in foot candles on the ground (on horizontal plane)?
6—Use from 0.1 to 3 fc.

Substation Receptacle Outlets

- 1 Do you provide receptacles in the substation for hand lamps or small portable motors?
7—Provide receptacles.
4—Do not provide receptacles.
- 2 Are the receptacles mounted on the substation structure, or on lighting posts, or in some other manner?
All mount the receptacles on the structures.
- 3 What is the average spacing of receptacles?
Majority have only one receptacle.
- 4 Is the receptacle wiring system single or 3 phase and what voltage?
All use single phase, 115 v.
- 5 Is the receptacle fed from the same branch circuit as the adjacent lighting units or is it connected to a separate circuit?
4—Use the same circuit as lighting.
3—Use separate circuits.

Manhole Lighting and Outlets

- 1 Do you install permanent lighting in your power and control cable manholes?
Majority have no manholes.

Lighting Cables

- 1 What is the cable size, type, insulation and covering used for feeding the lighting units and receptacles?
7—Use No. 10, 12 or 14 rubber covered, lead covered cable.
2—Use No. 10 or 19/22 rubber covered, lead covered "Parkway" cable.
- 2 Are the lighting cables installed in fiber or iron ducts, armored cable laid directly in ground, or installed in some other manner?
Lead covered and braided cables are installed in iron conduit.
"Parkway" cable is laid directly in the ground.
- 3 How is the cable protected if laid directly in the ground?
All use no covering over "Parkway" cable.
- 4 Is braided or lead covered cable used from the ground to the lighting unit?
4—Use braided cable.
3—Use lead covered cable.
- 5 How are the lighting fixtures grounded?
9—Use no special grounding, but mount fixtures on grounded steel structures or connect them to the conduit system.

6 What provisions are made for grounding portable hand lamps, etc.?

9—Make no provision.

1—Uses a separate No. 8 all-rubber insulated wire permanently attached to appliance. A test clip on the other end of the wire is clamped to the nearest ground.

The following fifteen (15) companies contributed data on illumination de-

sign for outdoor substations in Class III, a small rural transformer substation.

Cleveland Electric Illuminating Company

Consumers Power Company

Dallas Power and Light Company

The Detroit Edison Company

Electric Bond and Share Company

Houston Lighting and Power Company

Kansas Gas and Electric Company

The Milwaukee Electric Railway and Light Company

Ohio Power Company

Oklahoma Gas and Electric Company

Public Service Company of Colorado

Public Service Company of Northern Illinois

Public Service Electric and Gas Company of New Jersey

Union Gas and Electric Company

Washington Water Power Company

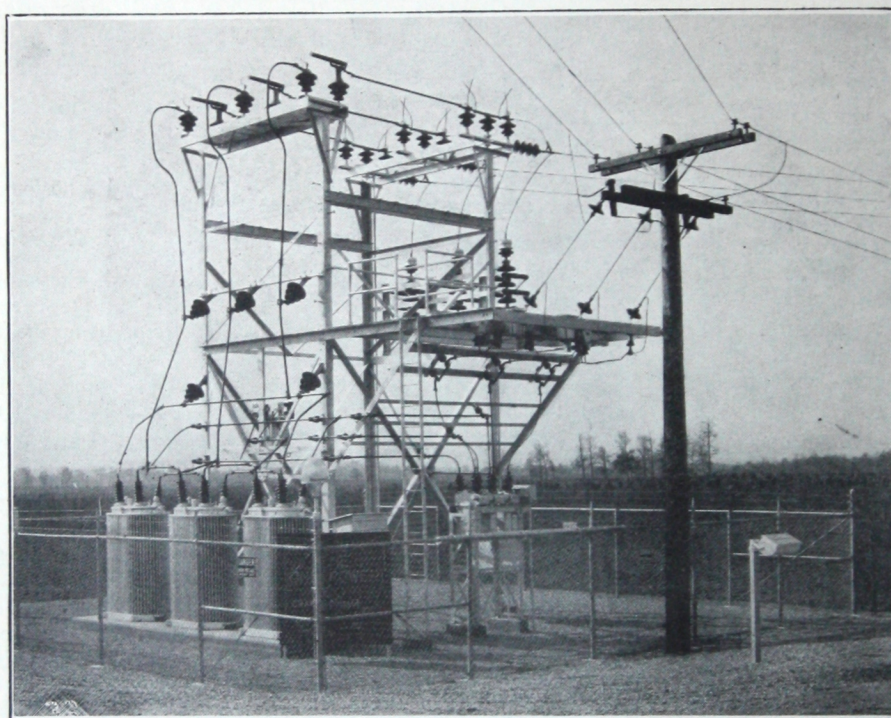
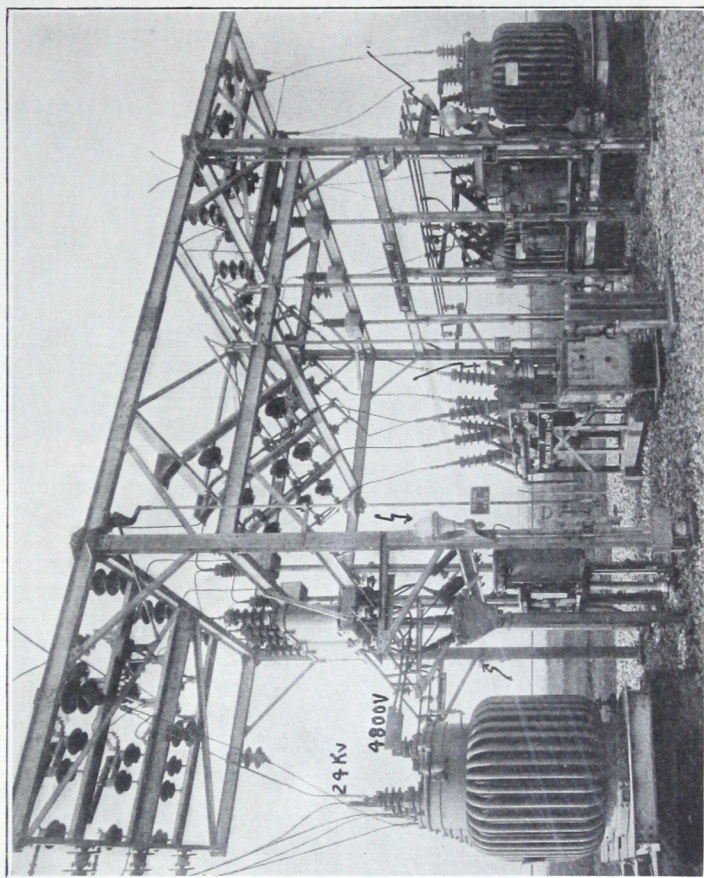
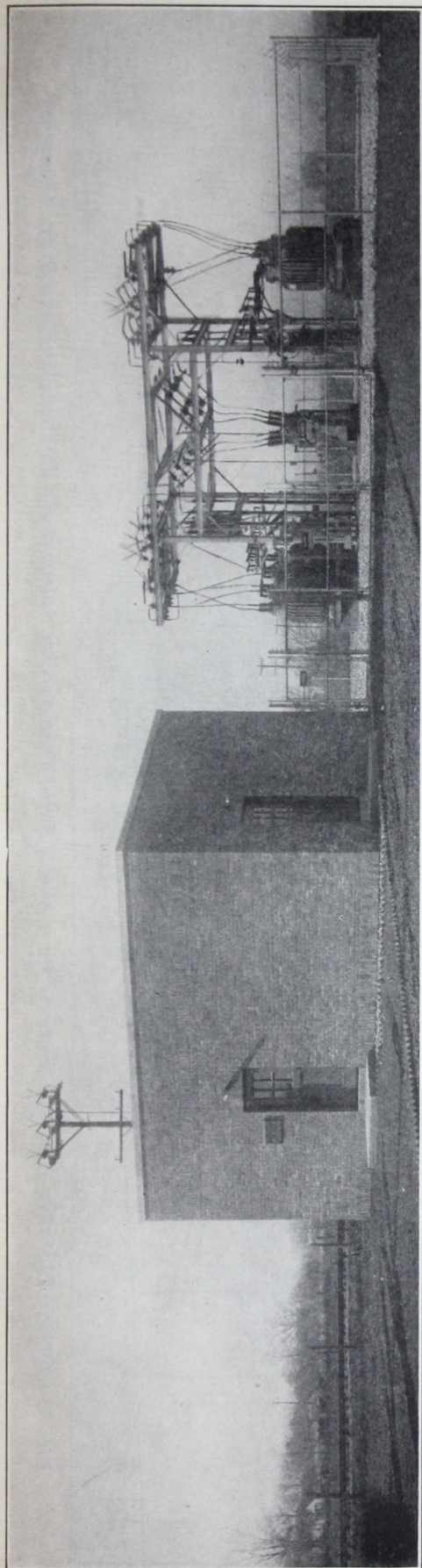


Fig. 30—Day View, Crawfis College Substation—Ohio Power Company



Figs. 31 and 32—Day View, Dundee Substation—The Detroit Edison Company

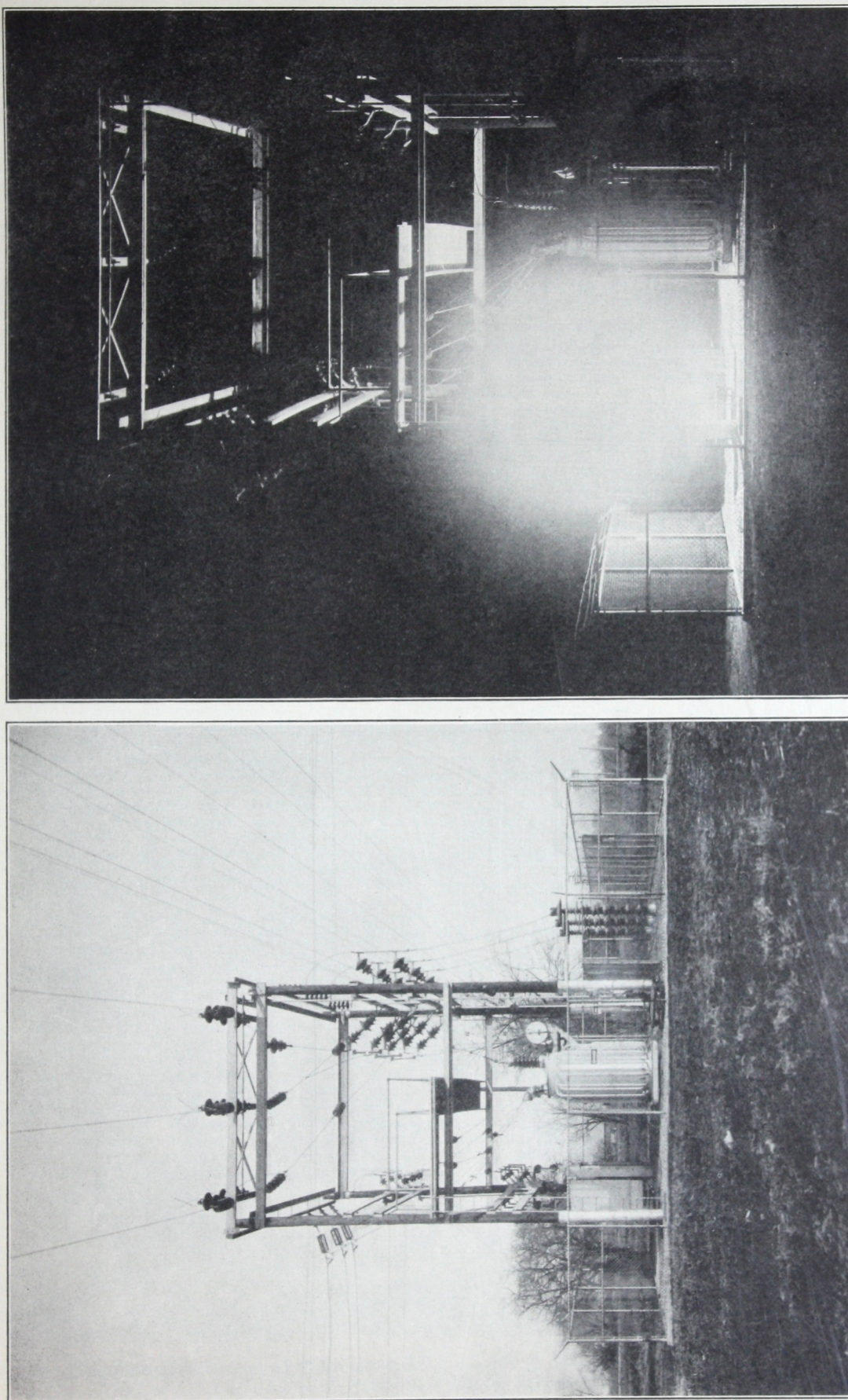


Fig. 33A—(Left) and Fig. 33B—(Right) Day and Night Views, 66/23.8 Kv Oklahoma City Oilfield Substation No. 2
Oklahoma Gas and Electric Company

Data Submitted by Manufacturers of Lighting Equipment

In order to combine for ready reference, manufacturers' latest available data on outdoor substation light-

ing equipment, a request was made of several leading manufacturers for the submission of material to the com-

mittee for its use. This material, in a somewhat condensed form, is submitted herewith.

CROUSE-HINDS COMPANY, SYRACUSE, N. Y.

General

Outdoor substations are lighted for 2 purposes: first, to make operation of the substation at night convenient and safe; second, for its advertising value, the lighted substation forming a community landmark.

There are 3 methods of lighting an outdoor substation in use at the present time; namely, overhead lighting, lighting with street lighting units and floodlighting. The first 2 systems mentioned have decided disadvantages and each system will be discussed as follows:

Overhead Lighting

The only advantage that can be assigned to overhead lighting is the first cost of the installation which is low. This system is absolutely wrong from a lighting standpoint as the operator must look directly into the light source in order to see the apparatus. This produces a glare in the eyes of the operator which makes it very difficult for him to see and increases the danger of operation of the station. It is also difficult to maintain the overhead units as they are mounted close to the high tension parts of the structure.

Street Light Units

The prismatic globe or street lighting unit has often been used for lighting outdoor substations with the units mounted 8 to 10 ft above the ground in the center of the bays and throwing their light upward. These units are inefficient when compared to floodlighting as the light distribution from the unit is uniform through 360 deg, and in a great many cases this entire distribution is not useful, and a large proportion of the light is thrown outside the structure where it is of no value. It is also impossible in case of an emergency when repairs are to be made and a very high intensity is desired on one particular part to refocus these units toward the point where repairs are being made.

Not only is the street light unit inefficient for floodlighting purposes but its wide distribution introduces a glare in the eyes of the observer which is contrary to good lighting practice. This glare spot forms an obstacle to vision and makes it more difficult to see the structure itself. An observer standing inside a station lighted in this manner is conscious of a distinct effort to overcome the glare of the units and to see the important points of the high tension structure such as disconnects.

This is very well illustrated in a set of photographs recently taken which are shown in Figs. 34 and 35. Fig. 34 was taken of an installation of a fairly large substation adjacent to a control building with floodlights mounted on the building to light the station and additional units mounted on a nearby transmission tower.

Fig. 35 shows a station lighted with the street light type units and this photograph was taken on the same night with exactly the same conditions so far as the camera was concerned, it being the same camera with stop F-8 and 3 min exposure in both cases, so that the comparison of light intensities should be accurate. An examination of these photographs will readily show the advantages of floodlighting.

Floodlighting

Floodlights mounted either directly on the substation structure or on poles adjacent to the structures provide the best all-around lighting for outdoor substations. The floodlights are efficient and project the light where it is needed. The light distribution is not fixed but is flexible as a number of combinations of reflector, lens and lamp can be made which will give any desired shape or spread of beam. In this way, the light from the lamp can be utilized in the most effective manner and all of the light can be thrown where it is useful.

The floodlighting system is flexible and in case of an emergency where repairs have to be made at one particular spot several of the units can easily be adjusted to throw their beams at this point so that it is lighted brilliantly and the repair work is facilitated. Usually the floodlights are equipped with either spread or diffusing lenses and in this case, the doors can be thrown open converting them to spotlights.

There are several types of outdoor substations and the type of floodlighting employed will depend somewhat upon the type of station and the available mounting places for floodlights. A large transforming and switching station located near a power house can often be lighted very economically by floodlights mounted on the roof or side of the building itself with additional units for lighting the other side of the station and removing shadows mounted either on poles at the other sides of the station or on transmission towers where these are located conveniently. Floodlights of 500 w such as type ADA-14 are generally used. These would be equipped with diffusing lenses where they are mounted very close to the structure or with horizontal spread lens if mounted at a greater distance.

For lighting compact substations which have an overhead structure which can readily support the conduit system for feeding the floodlights such as that shown in Figs. 37 and 38 the ideal lighting job can be obtained by using 200 w floodlights such as type ADA-12 mounted on the structure itself and equipped with 200 w, PS-30 bulb lamp and diffusing lenses. This, of course, is a more expensive installation but will give more uniform lighting. It can be fed either from conduit system run overhead or from underground wiring as desired and as will be described later. The floodlights are usually mounted from 6 to 10 ft above the ground at a

height at which they are easily serviced and where they will not come in close proximity to high tension equipment.

In cases where there is no building near the substation which forms a convenient mounting place for floodlights, the units can either be mounted on wood poles or steel poles set for the purpose or they can be mounted on the fence surrounding the station where the fence is of such construction that the conduit can be run around the top of the fence and floodlights mounted on the conduit. Where floodlights are mounted on the fence, 200 w units will be found to be most practical as they will be comparatively close to the structure. Where they can be mounted on separate poles at a greater distance from the station, a few 500 w floodlights will make a more economical installation although the light distribution will not be as even.

In the case of a small rural substation, the use of from 2 to 4—200 w type ADA-12 floodlights with diffusing lenses will usually be found adequate. If only 2 units are used, they should be mounted at diagonally opposite corners and if 4 units are used, one mounted at each corner.

There are some cases where lighting is desired only for emergency repairs and in this case, sometimes a pilot house control is installed similar to the installation in Fig. 39, of the type SDX-12 250 w searchlight with a control handle mounted where it can be conveniently reached from the ground and the searchlight mounted where the beam can easily be trained on any part of the structure.

Suggested methods of installation are shown in the following. Fig. 47 shows the installation of one floodlight on top of a steel post. Fig. 48 shows details of mounting one or two 500 or 1,000 w type ADA floodlights on a wood pole with the wiring details. Fig. 49 shows one method of mounting floodlights on the roof of a building which could be used where the parapet around the roof is not too high and which does not require the units being tied into the roof as the concrete block is movable and yet heavy enough to hold the unit in position. Fig. 50 shows the details of how the ADA-12 floodlights can be mounted directly on the substation structure using in one case conduit nipples to support the floodlight and in the other case a special bolt base which can be bolted directly to the structure. It is also suggested in this case that at various parts of the structure, extra receptacles be mounted for connecting portable tools or hand lamps. Fig. 51 shows how floodlights can be installed on the ground throwing the light directly upward. This may be found to be convenient when no other mounting place is available and districts where there are no heavy snows. There are several different wiring methods shown for this installation.

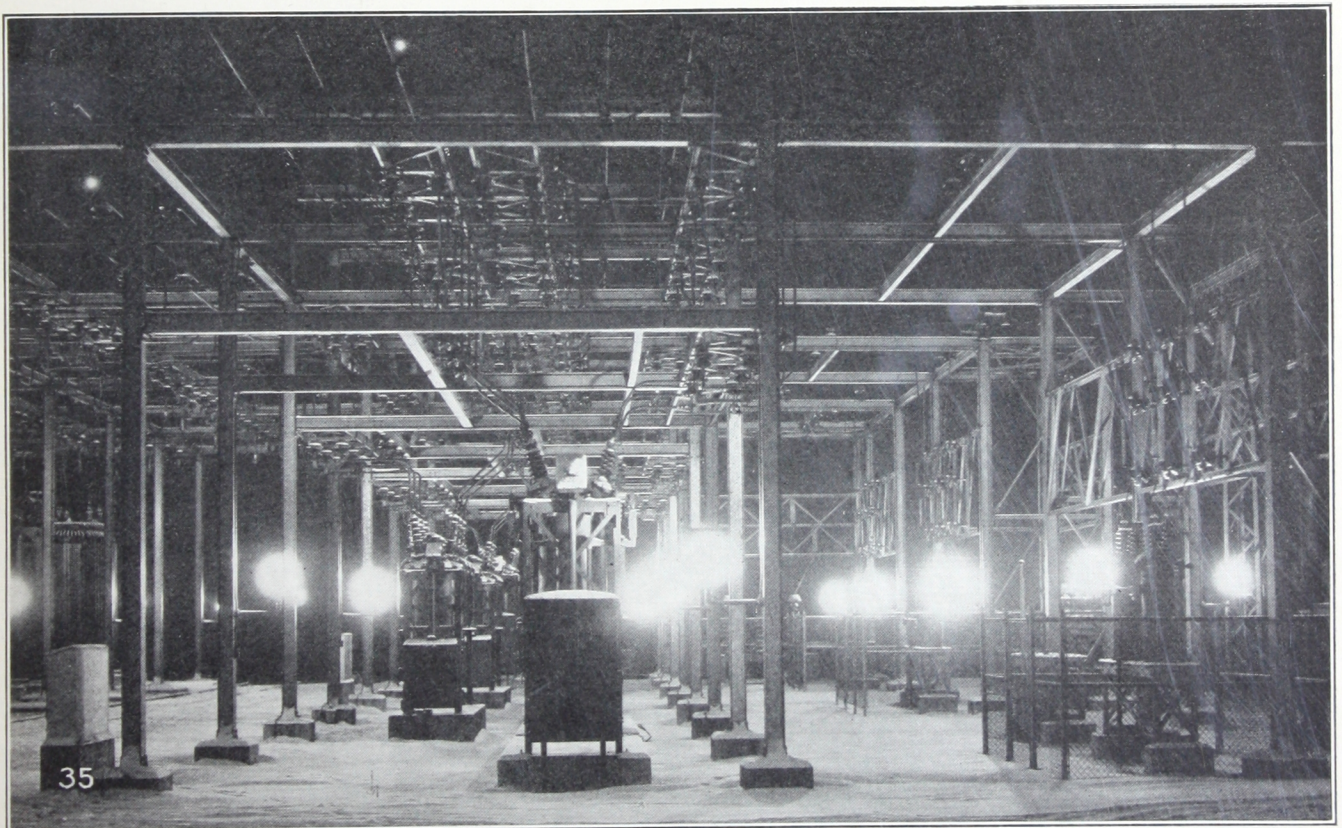
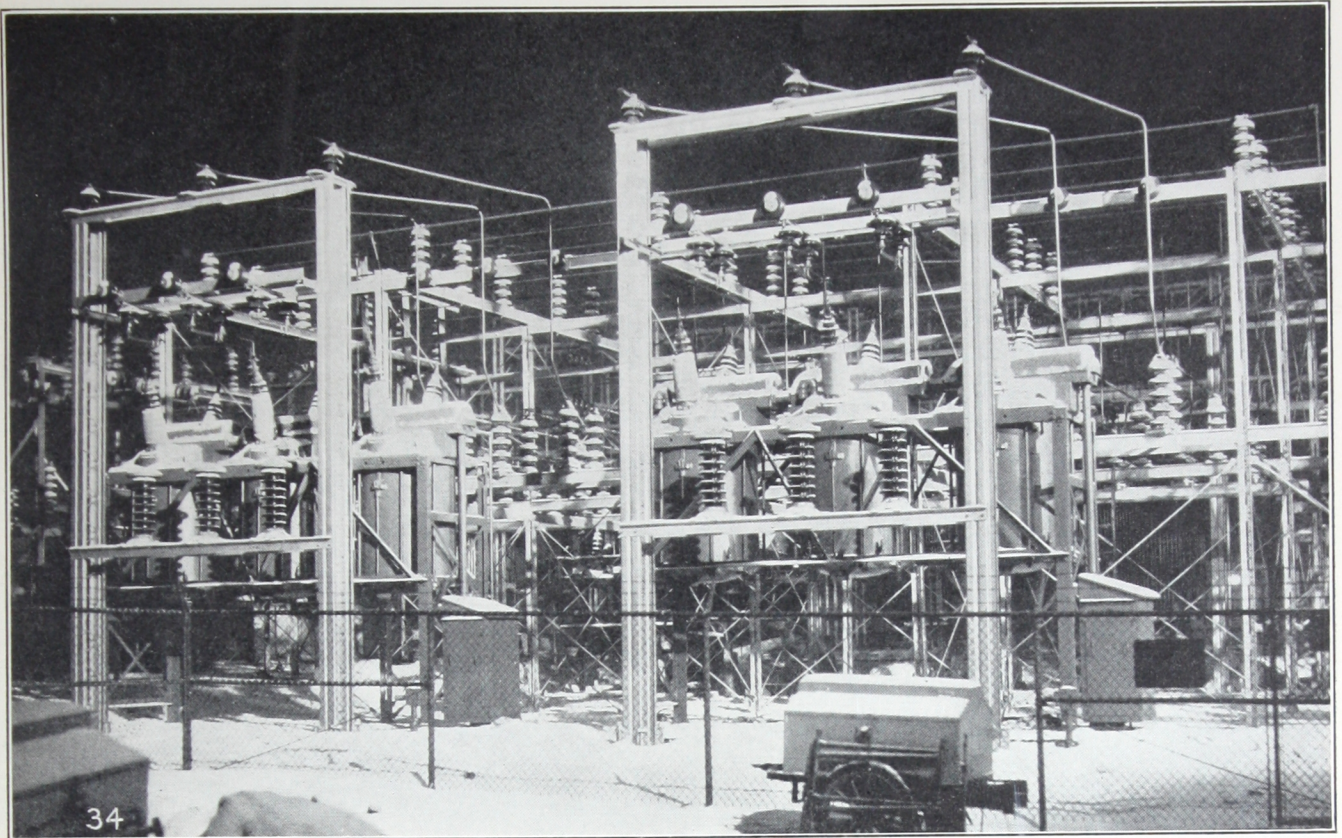


Fig. 34—Outdoor Substation Lighted with ADA-14, 500 W Floodlights; Fig. 35—Outdoor Substation Lighted with Prismatic Globe Street Lighting Units

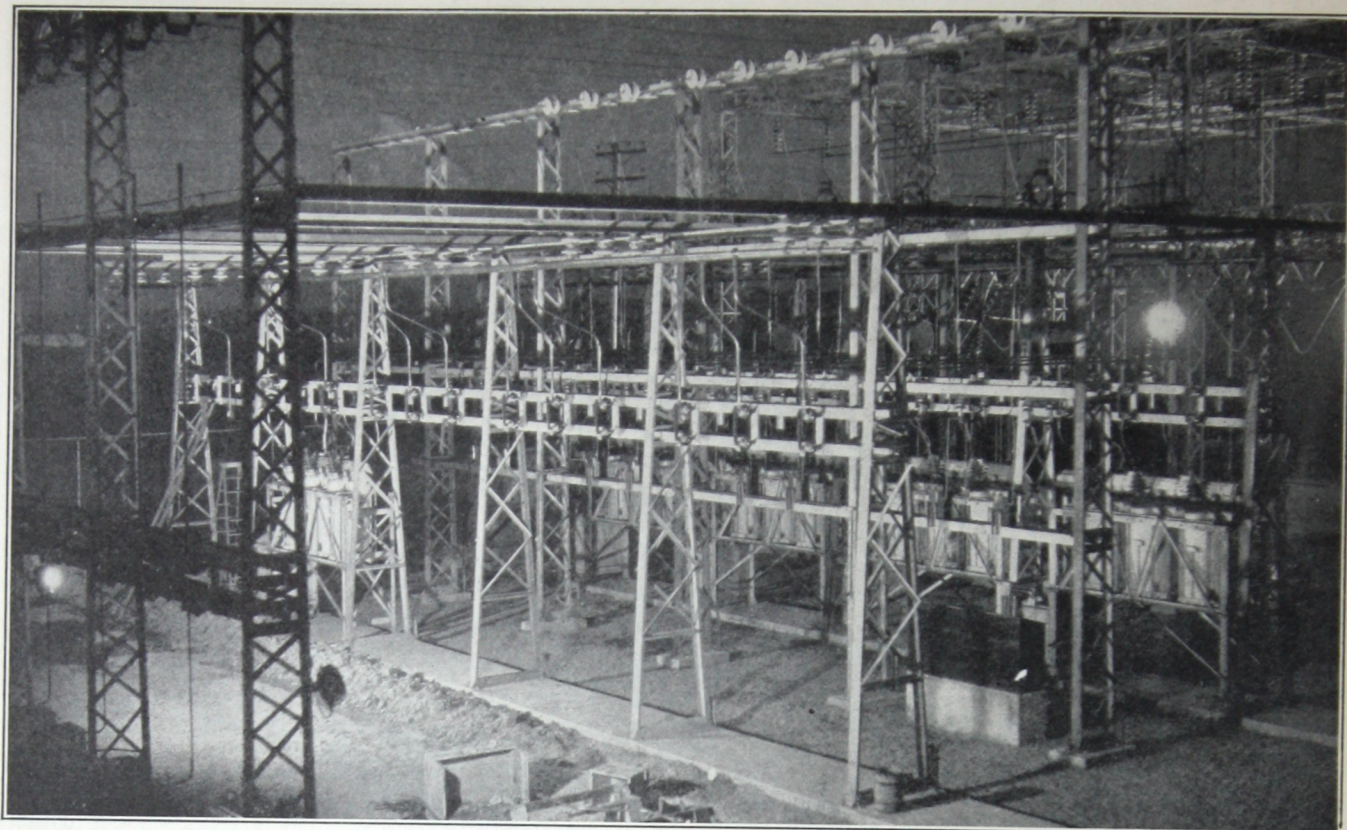


Fig. 36—Substation Lighted with ADA-14 Floodlights

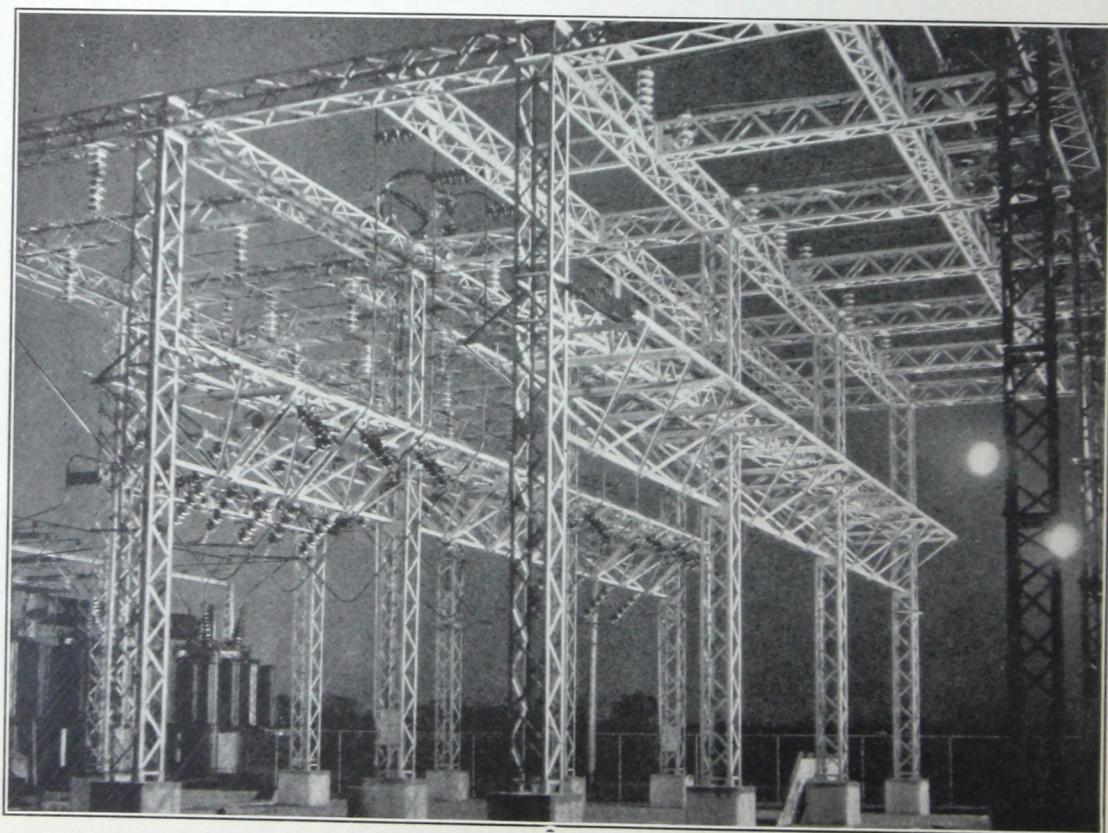


Fig 37—Substation Lighted with 200 W Floodlights Mounted on Steel Structure

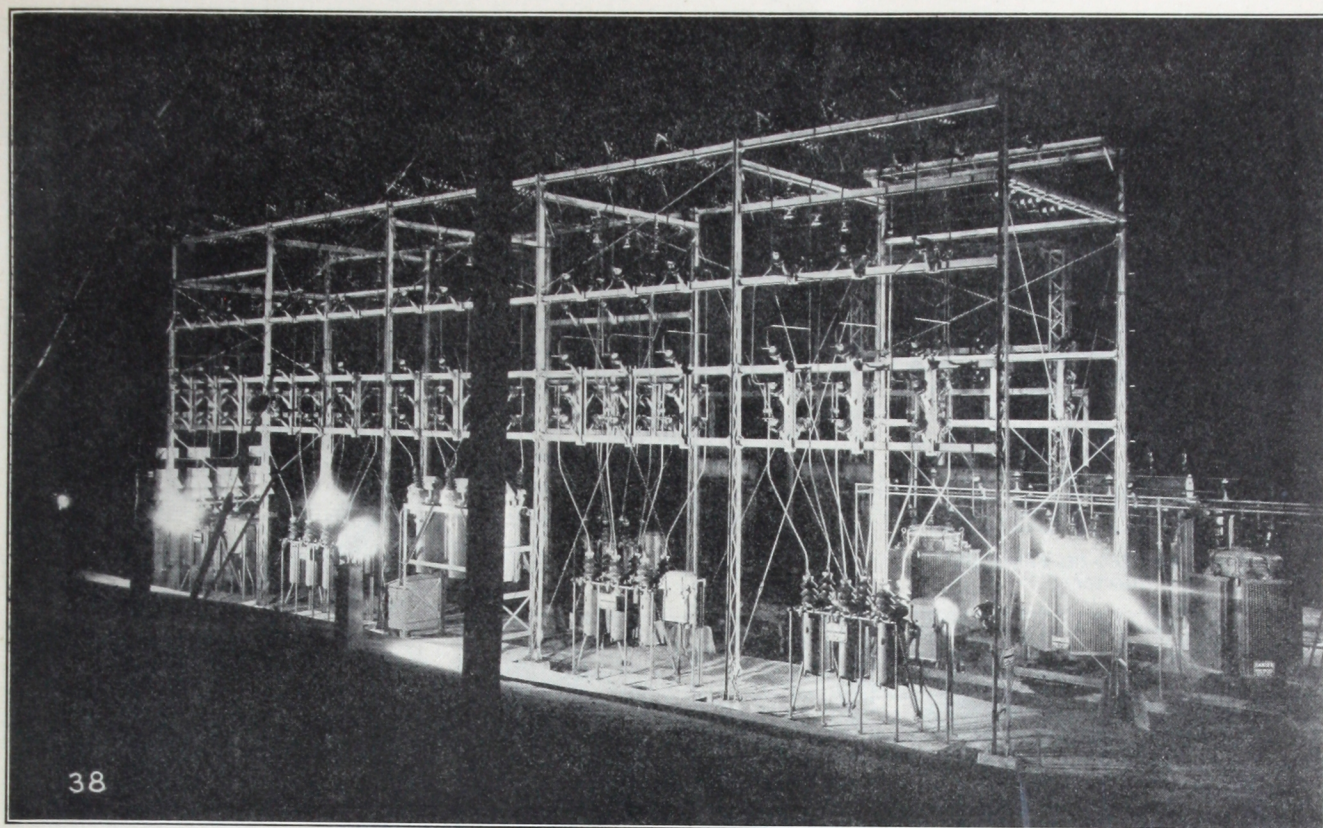


Fig. 38—Substation Lighted with 200 W Floodlights Mounted on Steel Structure and Adjacent Low Poles

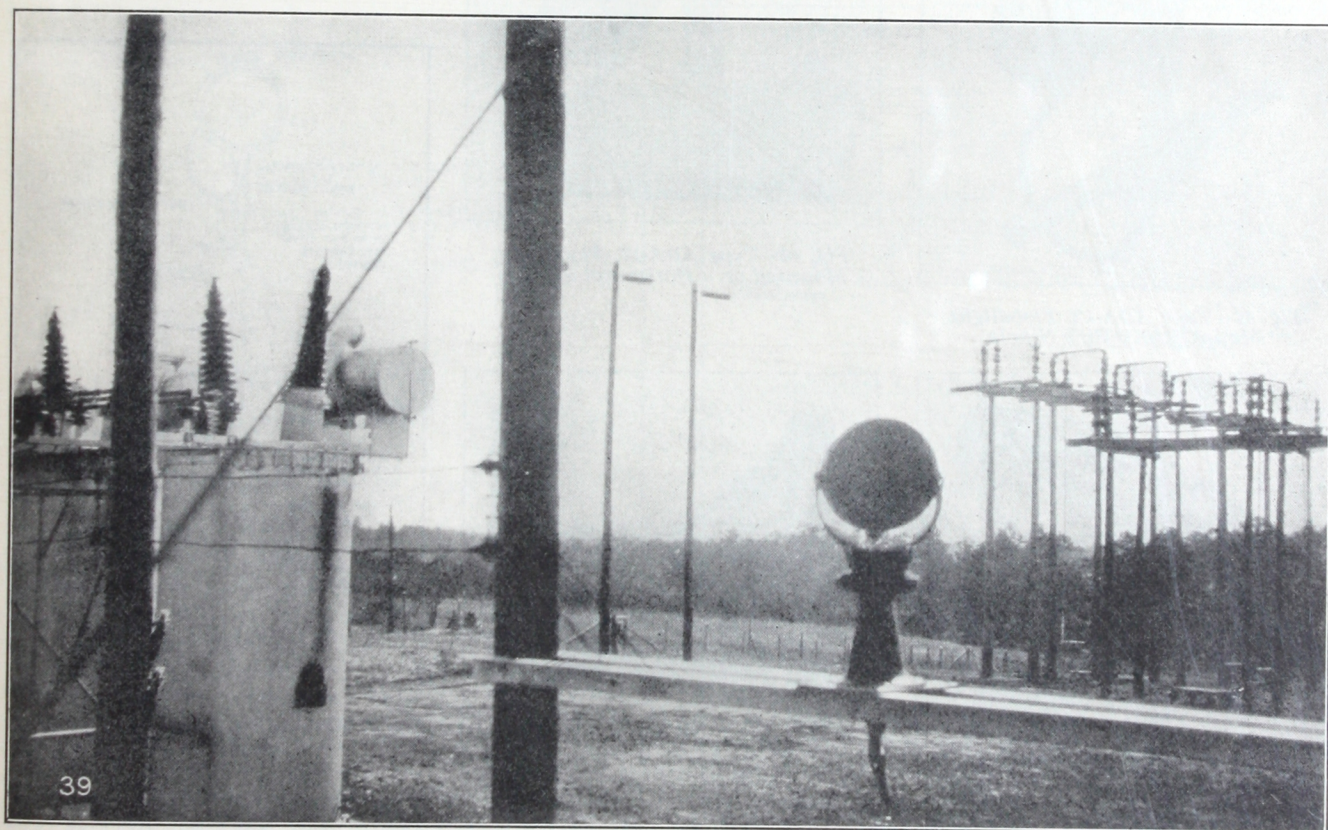


Fig. 39—Searchlight with Lever Control for Emergency Use at Outdoor Substations

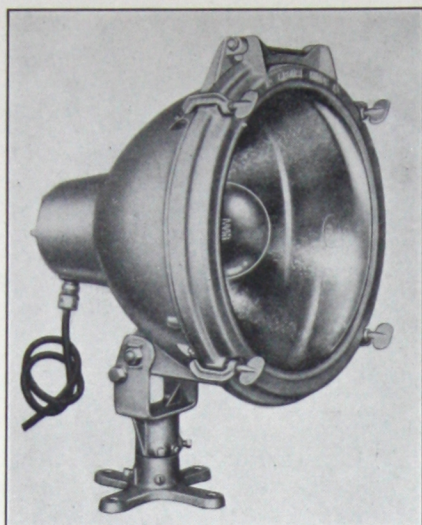


Fig. 40—Type ADA-14, Floodlight Projector

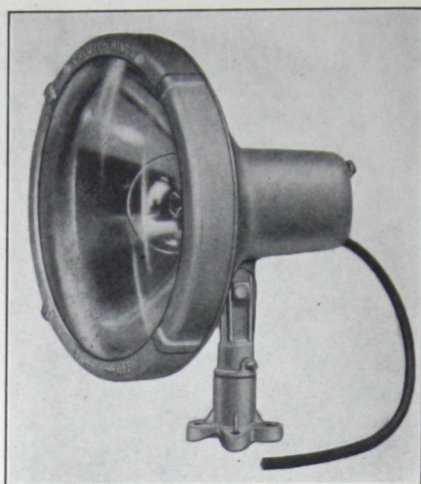


Fig. 43—Type ADA-12, Floodlight



Fig. 46—Type ADA-14, Floodlight Projector



Fig. 41—Type ADA-12, Floodlight Mounted on a Pipe Nipple

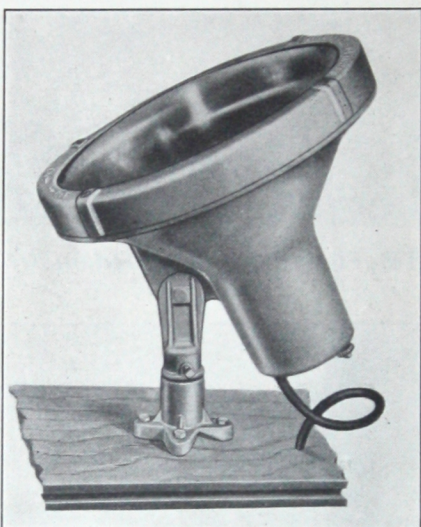


Fig. 44—Type ADA-12, Floodlight Mounted on a Horizontal Surface



Fig. 42—Type ADA-12, Floodlight Clamped to a Pipe with U Bolts

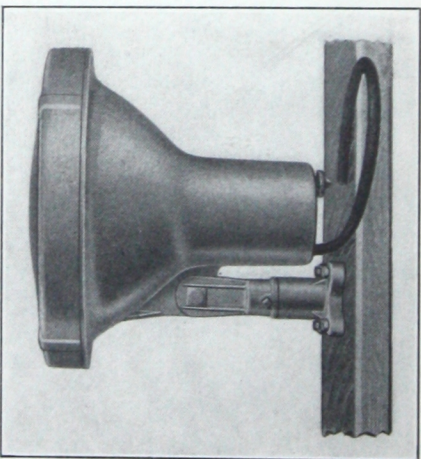


Fig. 45—Type ADA-12, Floodlight Mounted on a Vertical Surface

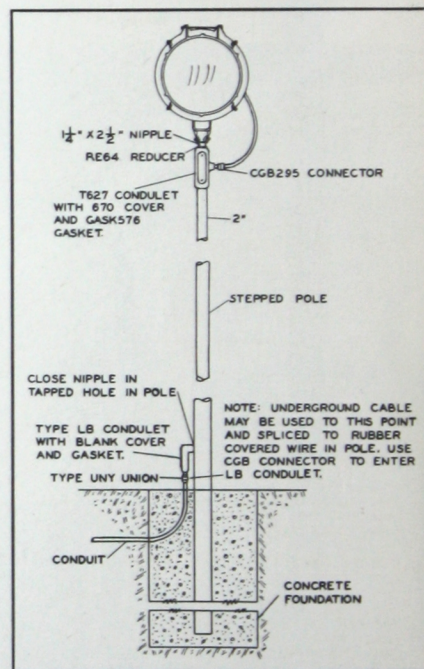
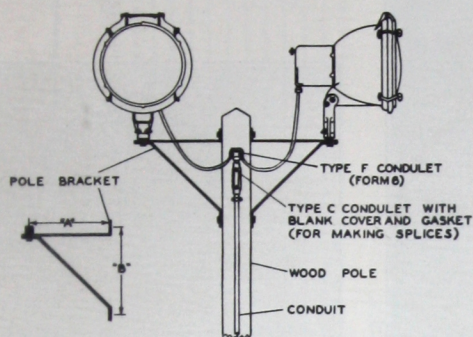
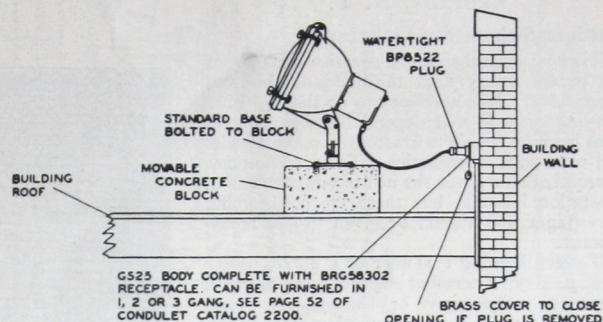


Fig. 47—Mounting Details for Floodlight on Steel Pole

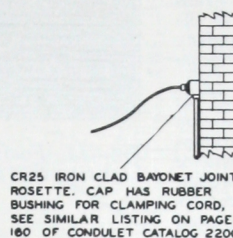


MOUNTING DETAILS					
FOR TYPE FLOODLIGHT	BRACKET NUMBER	DIM. "A"	DIM. "B"	MOUNTING HOLES NO.	SIZE
ADA-14, ADE-14, ADA-16	HL 2632	18"	19"	2	11/16"
LCE-20, LCE-1020, LCE-24	HL 2630	18"	19"	4	11/16"
MSA-1	HL 9928	18"	19"	4	11/16"

NOTE: SPACING OF HOLES SHOWN ABOVE IS APPROXIMATE. COMPLETE DIMENSIONAL DRAWINGS SENT UPON REQUEST.



ALTERNATE WIRING DETAIL NO. 1.



ALTERNATE WIRING DETAIL NO. 2.

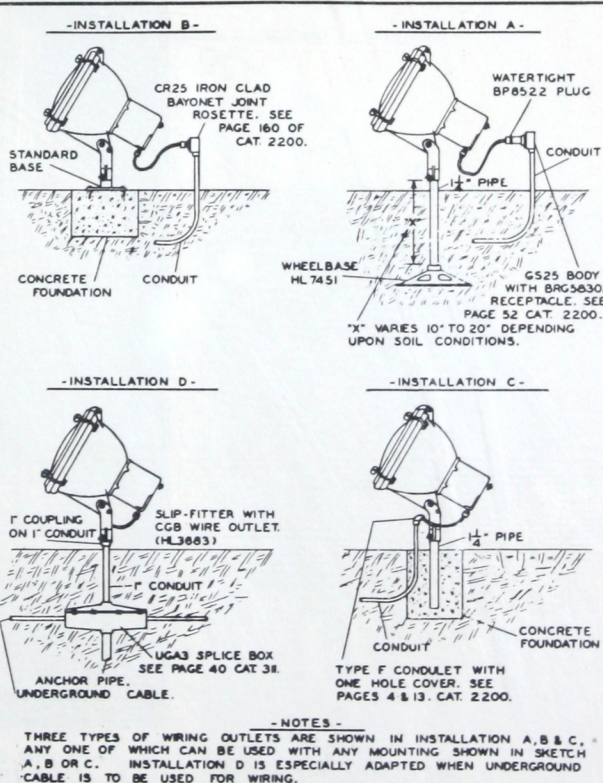
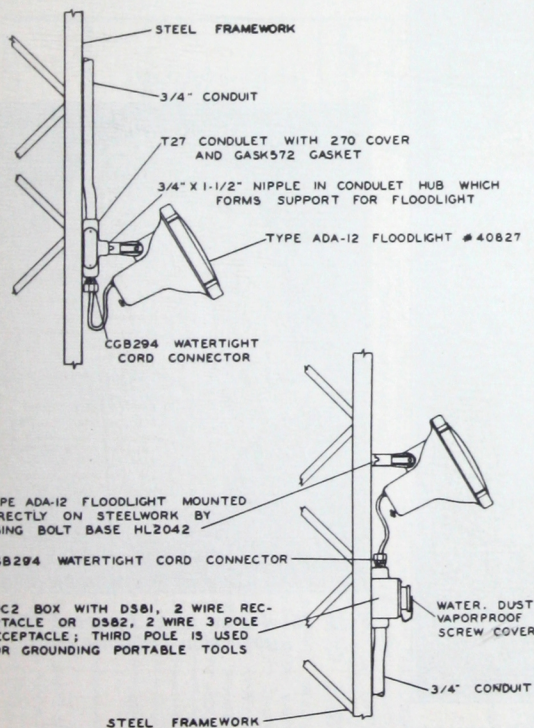
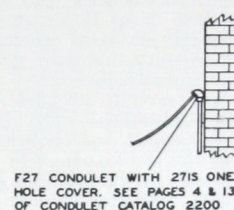


Fig. 48—(Upper Left) Pole Bracket Mounting; Fig. 49—(Upper Right) Mounting Details for Floodlight on Building Roof; Fig. 50—(Lower Left) Mounting Details for Floodlight on Steel Framework; Fig. 51—(Lower Right) Mounting Details for Floodlight on the Ground

GENERAL ELECTRIC COMPANY, SCHE-
NECTADY, N. Y.

Outdoor Substation Lighting

It is now general accepted practice throughout the public utility field to illuminate outdoor substations. It is necessary to do this to insure carrying on safe and dependable night operations and to enable operators to make repairs and cope with emergencies. These advantages or requirements cover the utilitarian purposes of substation lighting, but there are still further advantages that should be given proper recognition.

If every lighting customer of a public utility could be given a personal inspection trip through the many connections or channels necessary to supply electric service to the lamp holders of his home or shop, he would not only be greatly impressed with the efforts being made to insure him of continuity of service but would also be given an opportunity to marvel at the low cost of electrical energy. To accomplish the above is, of course, impossible. A properly illuminated outdoor switching structure offers a means of calling these things to the attention of the public. By this means an operating company can also transform a substation structure into a spectacle or unusual night display.

There are several accepted methods of illuminating substations. The large station prominently situated deserves lighting in keeping with its size and location. In this instance ornamental standards are justified and represent good practice. Smaller stations or stations not so prominently situated can best be treated with bracket Novalux units or floodlighting projectors.

The energy consumed in lighting a station is obviously not important to the operating company. It cannot be urged too strongly that careful consideration be given the design to insure sufficient illumination so the many benefits both direct and indirect will be realized.

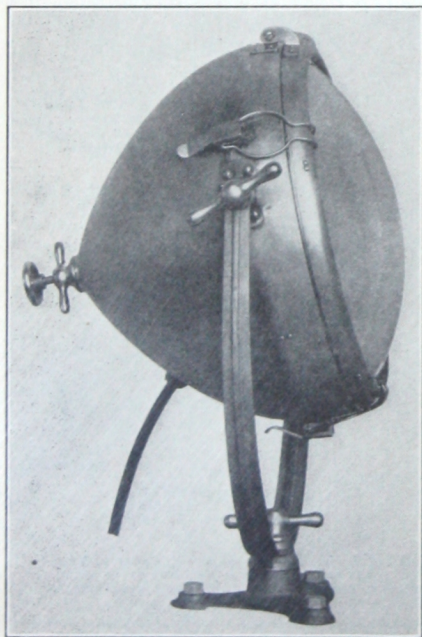


Fig. 52—Type L30 Novalux Floodlighting Projector



Fig. 53—Form 12 Combination Street Lighting and Floodlighting Novalux Unit



Fig. 54—Form 12 Novalux Ornamental Unit, 118 Rippled Globe

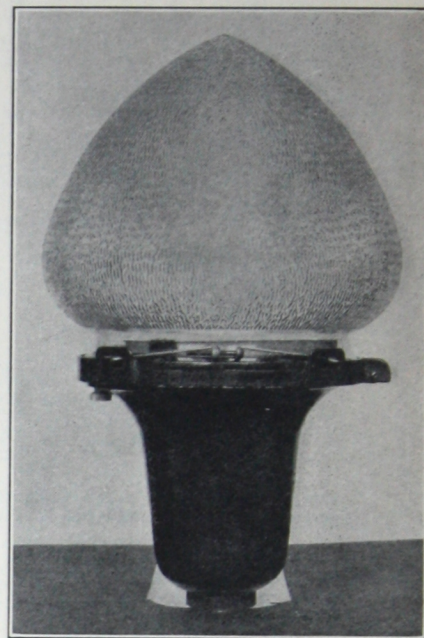


Fig. 55—Form 54 Multiple Outdoor Substation Lighting Unit



Fig. 56—Form 25A Inverted Outdoor Substation Lighting Unit

FORM 12 COMBINATION FLOODLIGHTING AND STREET LIGHTING UNIT

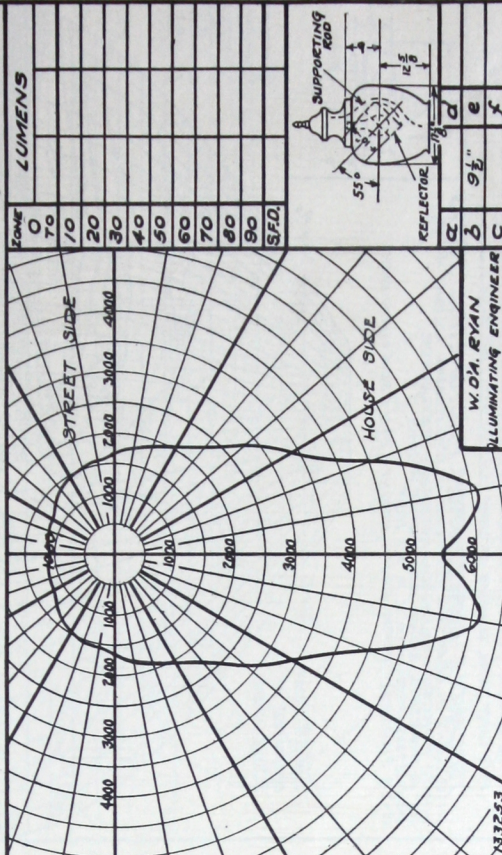
LYNN WORKS, GENERAL ELECTRIC CO.
1000 WATT MAZDA C MULTIPLE LAMP, PS-52 BULB

LAMP	CLEAR
VOLTS	115
AMPERES	870
WATTS (RATED)	1000
MEAN HEMISPHERICAL C.P.	
WATTS PER MEAN HEMISPHERICAL C.P.	
DOWNWARD LUMENS	
DOWNWARD LUMENS PER WATT	1138
MEAN SPHERICAL C.P.	0.88
WATTS PER MEAN SPHERICAL C.P.	14300
TOTAL LUMENS	
TOTAL LUMENS PER WATT	14.3
PER CENT TOTAL LUMENS OF LAMP	71.4

PHOTOMETRIC TEST

PHOTOMETRIC TEST

DISTRIBUTION OF INITIAL CANDLE-POWER IN THE 14-5° CONE



READINGS TAKEN AT 2.5 FT. RADIUS
CLEAR LAMP OPERATED AT 20000 TOTAL LUMENS
#118-1118 MEDIUM ALABASTER RIPPLED GLASSWARE
INTERNAL SILVERED GLASS REFLECTOR. CAT.#12X33/
REFLECTOR ADJUSTED FOR MAX. C.P. AT .35" ABOVE HORIZONTAL
UNIT TESTED WITHOUT AUXILIARY 200 WATT LAMP

Fig. 58—Distribution Curve for Form 12 Combination Floodlighting and Street Lighting Unit

FORM 12 COMBINATION FLOODLIGHTING AND STREET LIGHTING UNIT

LYNN WORKS, GENERAL ELECTRIC CO.
1000 WATT MAZDA C MULTIPLE LAMP, PS-52 BULB

TRANSFORMER		CLEAR
LAMP		
VOLTS	115	
AMPERES	2.70	
WATTS (RATED)	1000	
MEAN SPHERICAL CANDLES	113.8	
WATTS PER MEAN SPHERICAL CANDLE	0.88	
TOTAL LUMENS	14200	
TOTAL LUMENS PER WATT	14.3	
TOTAL EFFICIENCY OF LAMP	71.4	

ISOCANDLE CURVES FROM PHOTOMETRIC TESTS

UNIT TESTED WITHOUT AUXILIARY 200 WAT LAMP
REFLECTOR ADJUSTED FOR MAX.C.P. AT 55° ABOVE HOR
INTERNAL SILVERED GLASS REFLECTOR CAT.#12X321
MEDIUM ALABASTER RIPPLED GLASSWARE
#18-1118

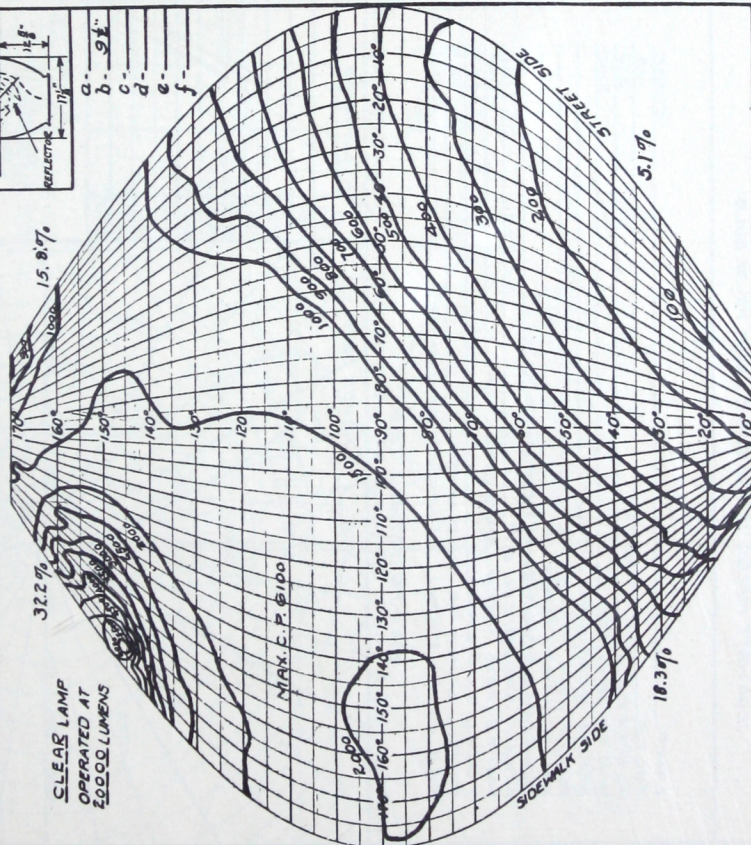


Fig. 57—Isocandle Curves for Form 12 Combination Floodlighting and Street Lighting Unit

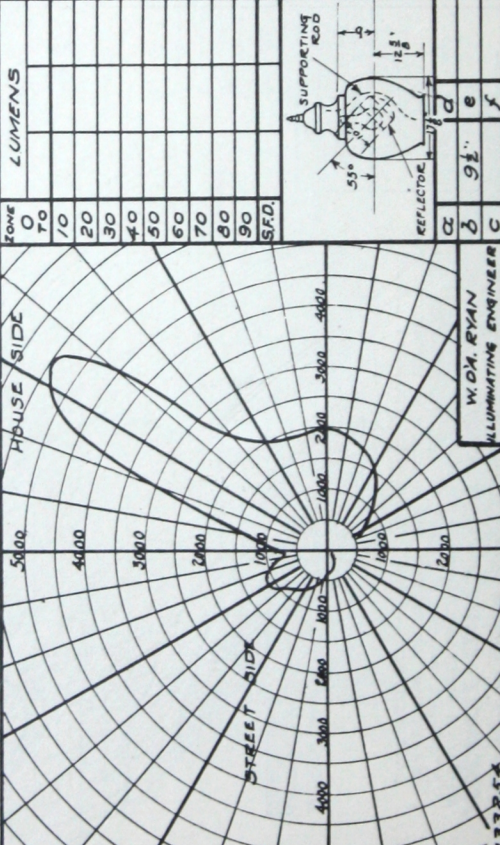
FORM 12 COMBINATION FLOODLIGHTING AND STREET LIGHTING UNIT

LYNN WORKS, GENERAL ELECTRIC CO.
1000 WATT MAZDA C MULTIPLE LAMP, PS-5Z BULB

LAMP	CLEAR
VOLTS	115
AMPERES	8.70
WATTS (RATED)	1000
MEAN HEMISPHERICAL C.P.	
WATTS PER MEAN HEMISPHERICAL C.P.	
DOWNWARD LUMENS PER WATT	
MEAN SPHERICAL C.P.	1138
WATTS PER MEAN SPHERICAL C.P.	0.88
TOTAL LUMENS	14300
PER CENT TOTAL LUMENS OF LAMP	14.3
PER CENT TOTAL LUMENS OF LAMP	11.4

PHOTOMETRIC TEST

DISTRIBUTION OF INITIAL CANDLE-POWER IN A VERTICAL PLANE AT RIGHT ANGLE TO CURB



READINGS TAKEN AT 25 FT. RADIUS
CLEAR LAMP OPERATED AT 20000 TOTAL LUMENS
#118-1118 MEDIUM ALABASTER RIPPLED GLASSWARE
INTERNAL SILVERED GLASS REFLECTOR CAT #12X321
REFLECTOR ADJUSTED FOR MAX. C.P. AT 35° ABOVE HORIZONTAL
UNIT TESTED WITHOUT AUXILIARY 200 WATT LAMP

Fig. 59—Distribution Curve for Form 12 Combination Floodlighting and Street Lighting Unit

FORM 25A NOVALUX SUBSTATION UNIT

LYNN WORKS, GENERAL ELECTRIC CO.
300 WATT MAZDA C MULTIPLE LAMP, PS-35 BULB

TRANSFORMER	CLEAR
LAMP	115
VOLTS	261
AMPERES	300
WATTS (RATED)	
MEAN SPHERICAL CANDLE	4110
WATTS PER MEAN SPHERICAL CANDLE	
TOTAL LUMENS	
PER CENT TOTAL LUMENS OF LAMP (ONE UNIT ONLY)	76.1

ISOCANDLE CURVES FROM PHOTOMETRIC TESTS

#118 LIGHT ALABASTER RIPPLED GLASS GLOBE, HEIGHT 4 1/8 IN.
WHITE SPHERICAL CANDLE REFLECTOR #4635
ADJUSTED FOR MAX. C.P. AT 103°
C-7A FILAMENT FORM 5.6MM, HEIGHT X 26.2 X 33.4 MM, WIDTH

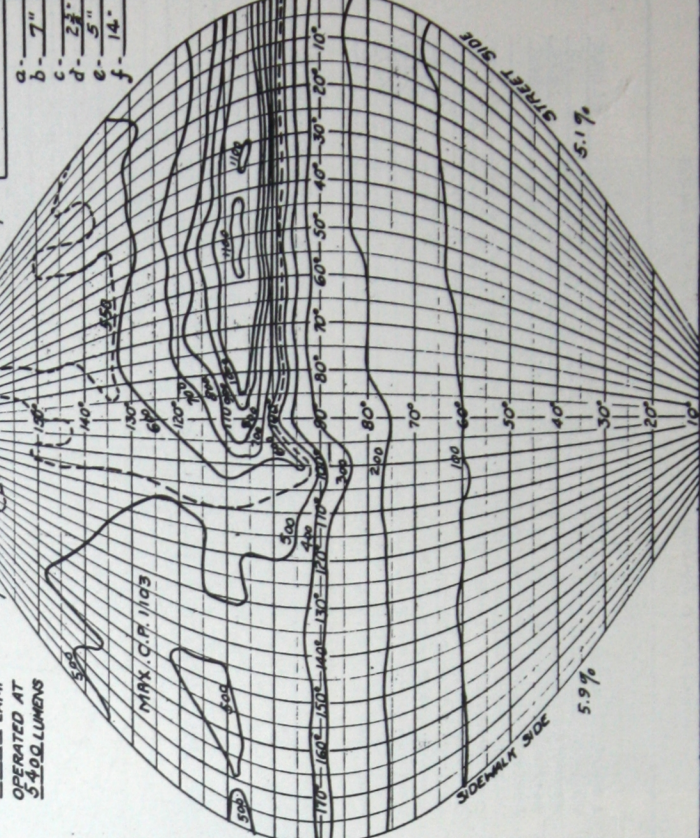
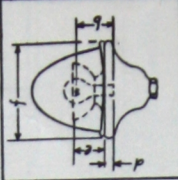
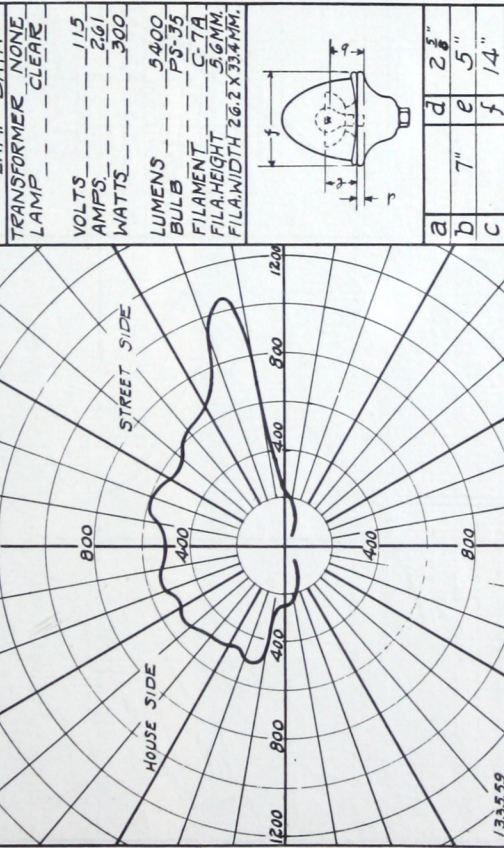


Fig. 60—Isocandle Curves for Form 25A Novalux Substation Unit

FORM 25A NOVALUX SUBSTATION UNIT
 LYNN WORKS, GENERAL ELECTRIC CO.
 300 WATT MAZDA C MULTIPLE LAMP, FS-35 BULB

DISTRIBUTION DATA				LIGHT FLUX VALUES		
ANGLE	ZONE 0° TO	LUMENS	CANDLES STREET SIDE	ZONE 0° TO	LUMENS	PERCENT OF LAMP
85°	212		500	0°-60°	62	1.1
75°	137		510	0°-90°	596	10.5
65°	94		598	0°-180°	4110	76.1
55°	58		580	% OF LAMP		
45°			542	DOWNWARD		
			605	STREET SIDE	5.1	
35°			637	UPWARD		
25°			733	STREET SIDE	38.1	
15°			1052	DOWNWARD		
5°			363	HOUSE SIDE	5.9	
0° RADIAL			245	UPWARD		
				HOUSE SIDE	27.0	
				TOTAL EFF.	76.1	

DISTRIBUTION OF INITIAL C.P. IN A VERTICAL PLANE AT RIGHT ANGLE TO CURB (ONE UNIT ONLY)



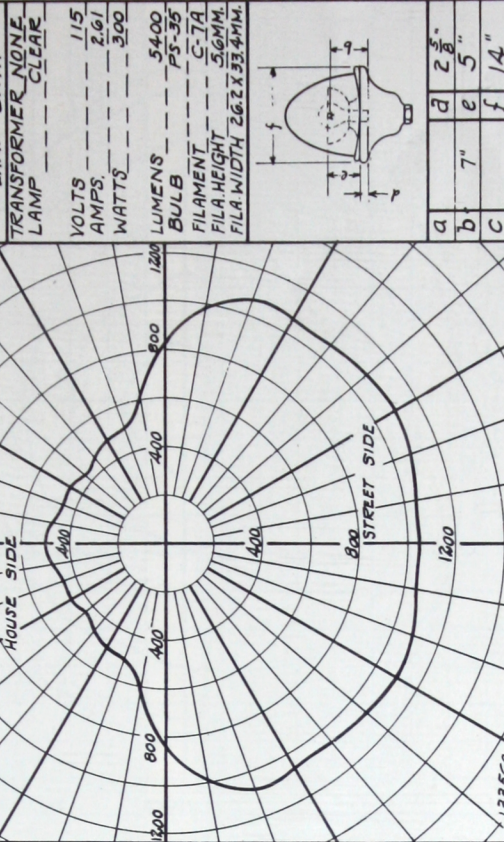
READINGS TAKEN AT 25 FT. RADIUS
 CLEAR LAMP OPERATED AT 5400 TOTAL LUMENS
 #116 LIGHT ALABASTER RIPPLED GLASS GLOBE (WEIGHT 4 LBS.)
 WHITE PORCELAIN ENAMEL INTERNAL REFLECTOR
 8 1/2" A-SYMMETRIC DOME REFRACTOR #4633
 ADJUSTED FOR MAX. C.P. AT 105°

Fig. 61—Distribution Curve for Form 25A Novalux Substation Unit

FORM 25A NOVALUX SUBSTATION UNIT
 LYNN WORKS, GENERAL ELECTRIC CO.
 300 WATT MAZDA C MULTIPLE LAMP, FS-35 BULB

DISTRIBUTION DATA				LIGHT FLUX VALUES		
ANGLE	ZONE 0° TO	LUMENS	CANDLES	ZONE 0° TO	LUMENS	PERCENT OF LAMP
80°	990		499	0°-60°	62	1.1
70°	1070		479	0°-90°	596	10.5
60°	1068		461	0°-180°	4110	76.1
50°	1073		460	% OF LAMP		
40°	1082		435	DOWNWARD		
30°	1103		460	STREET SIDE	5.1	
20°	1080		482	UPWARD		
10°	1054		504	STREET SIDE	38.1	
0°	1052		617	DOWNWARD		
				HOUSE SIDE	5.9	
				TOTAL EFF.	76.1	

DISTRIBUTION OF INITIAL CANDLE-POWER IN THE 105° CONE (ONE UNIT ONLY)



READINGS TAKEN AT 25 FT. RADIUS
 CLEAR LAMP OPERATED AT 5400 TOTAL LUMENS
 #116 LIGHT ALABASTER RIPPLED GLASS GLOBE (WEIGHT 4 LBS.)
 WHITE PORCELAIN ENAMEL INTERNAL REFLECTOR
 8 1/2" A-SYMMETRIC DOME REFRACTOR #4633
 ADJUSTED FOR MAX. C.P. AT 105°

Fig. 62—Distribution Curve for Form 25A Novalux Substation Unit

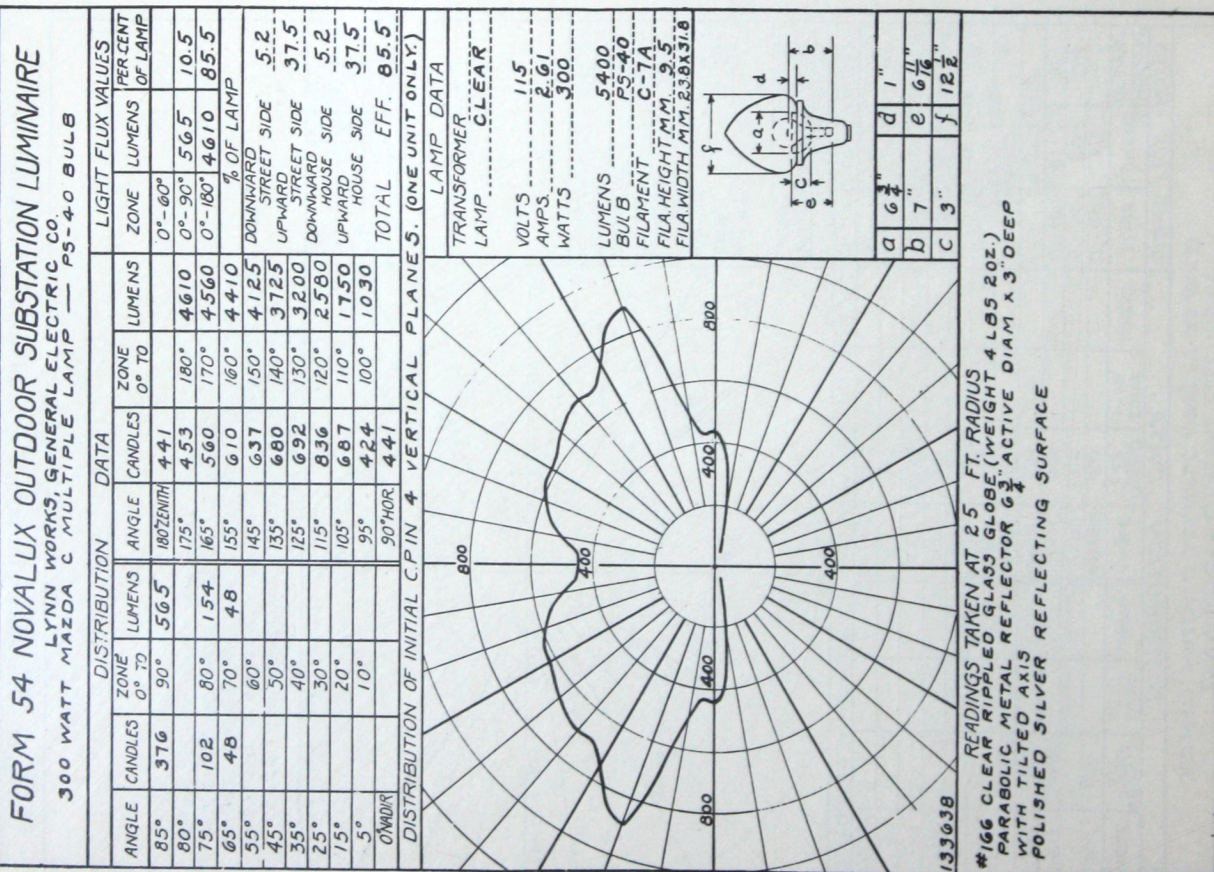


Fig. 63—Distribution Curve for Form 54 Novalux Outdoor Substation Lighting Unit

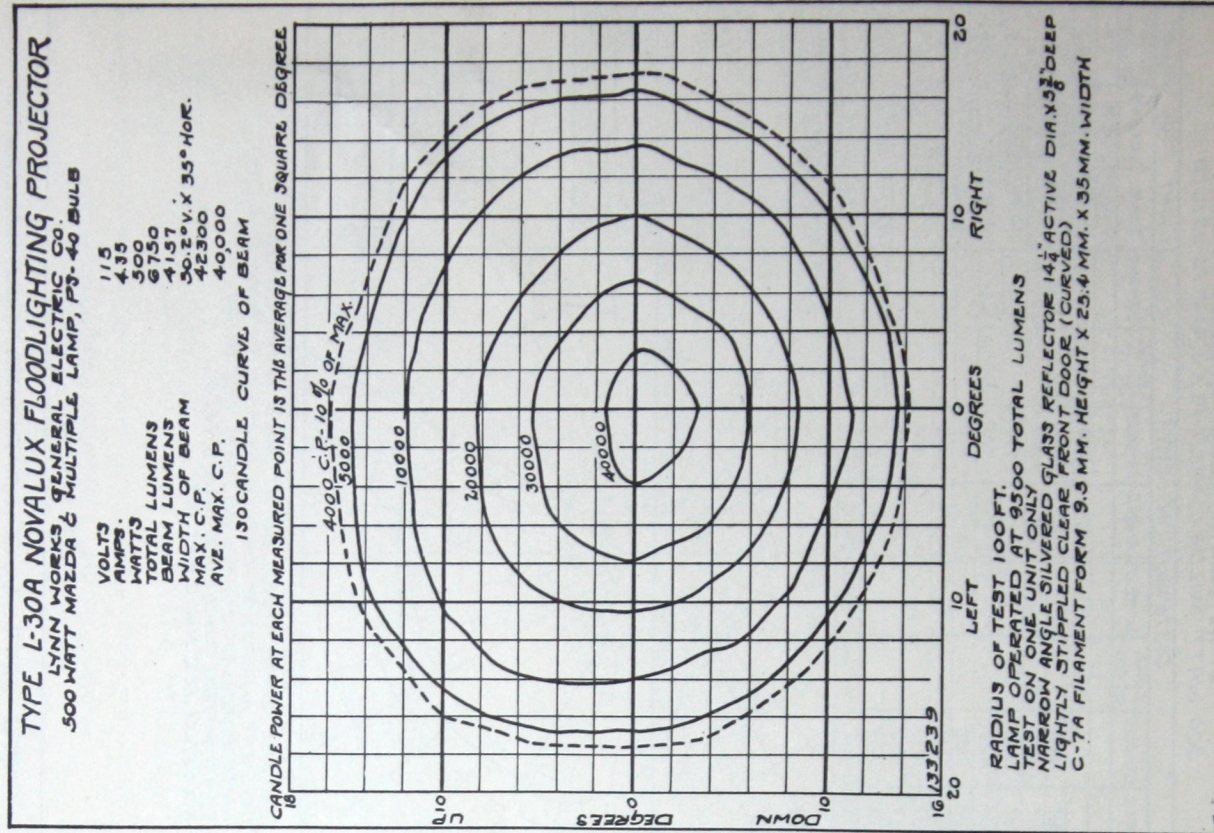


Fig. 64—Distribution Curves for Type L30A Novalux Floodlighting Projector

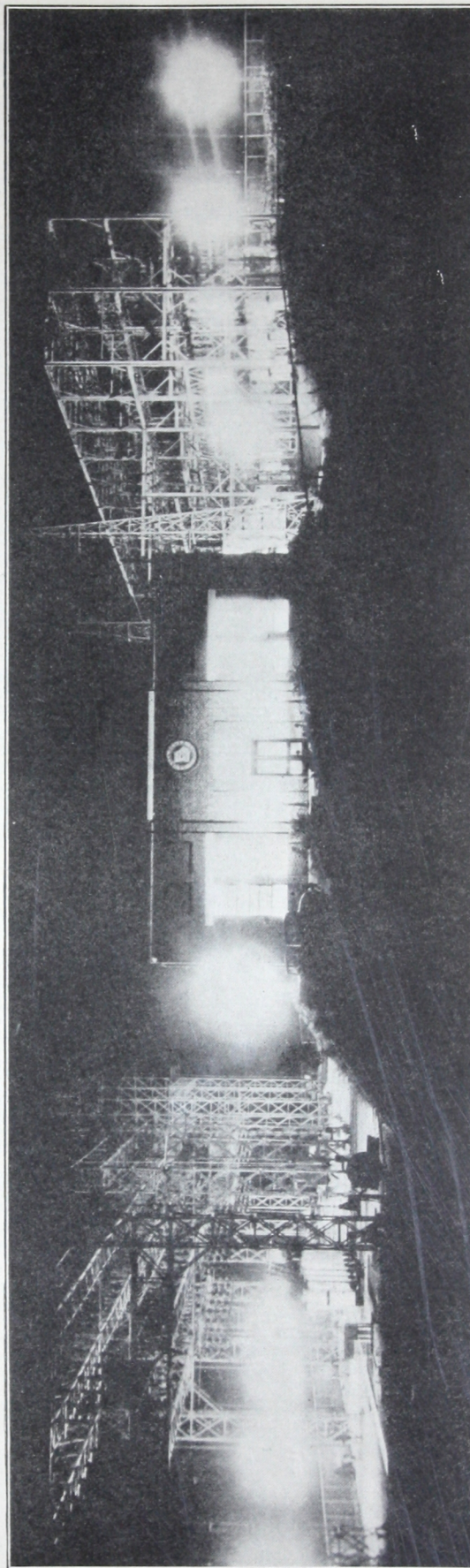
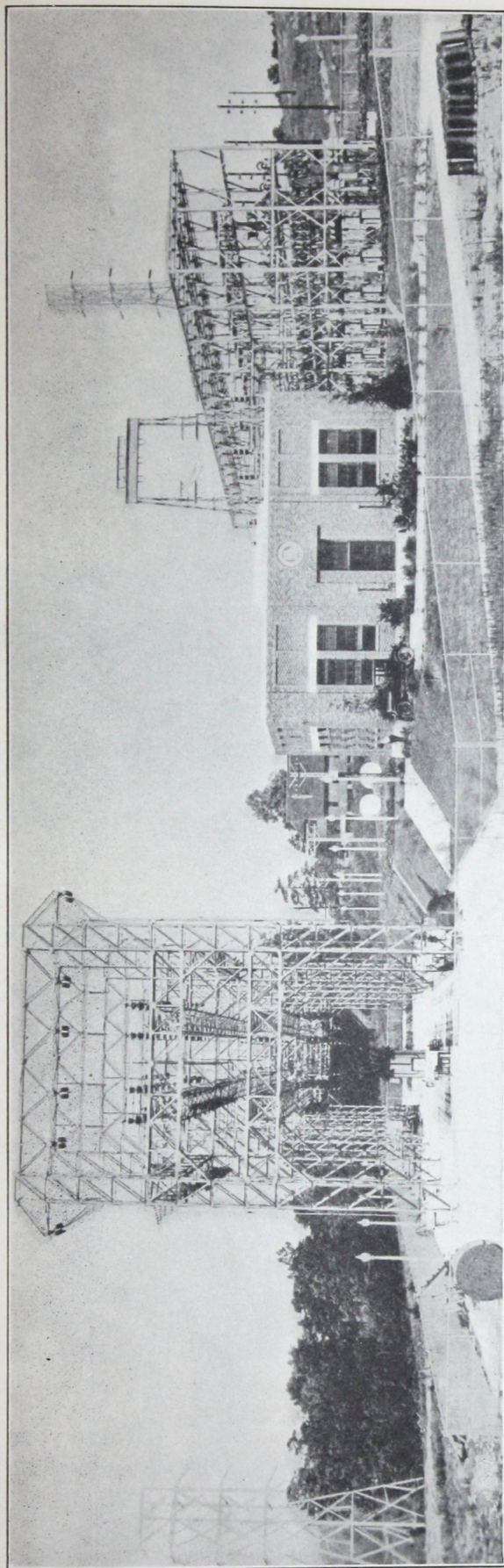


Fig. 65—Day View and Fig. 66—Night View, Outdoor Substation Equipped with Form 33 Novalux Combination Street and Floodlighting Units

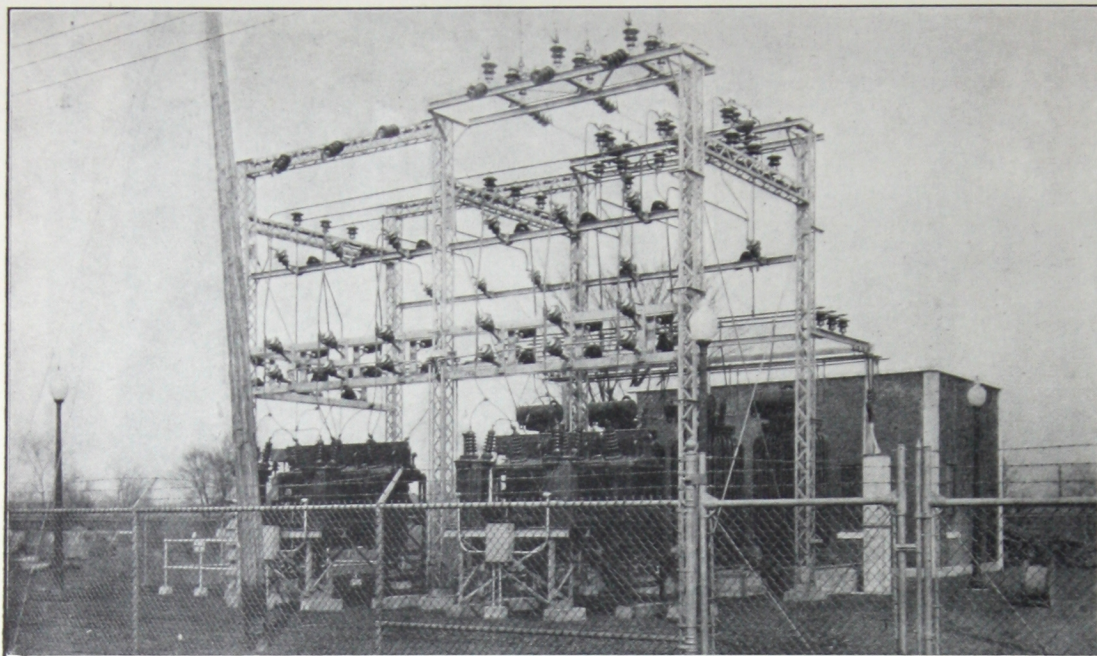


Fig. 67—Day View—Substation Equipped with Form 8 Ornamental Novalux Units

Fig. 68—(Right) Night View—Substation Equipped with Form 8 Ornamental Novalux Units

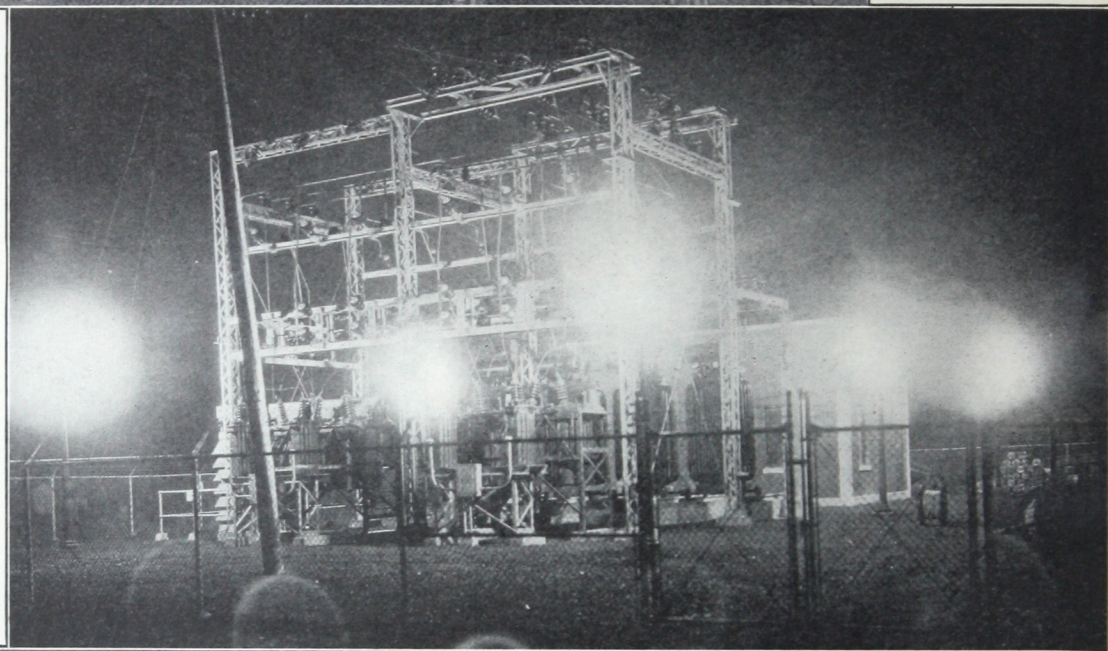
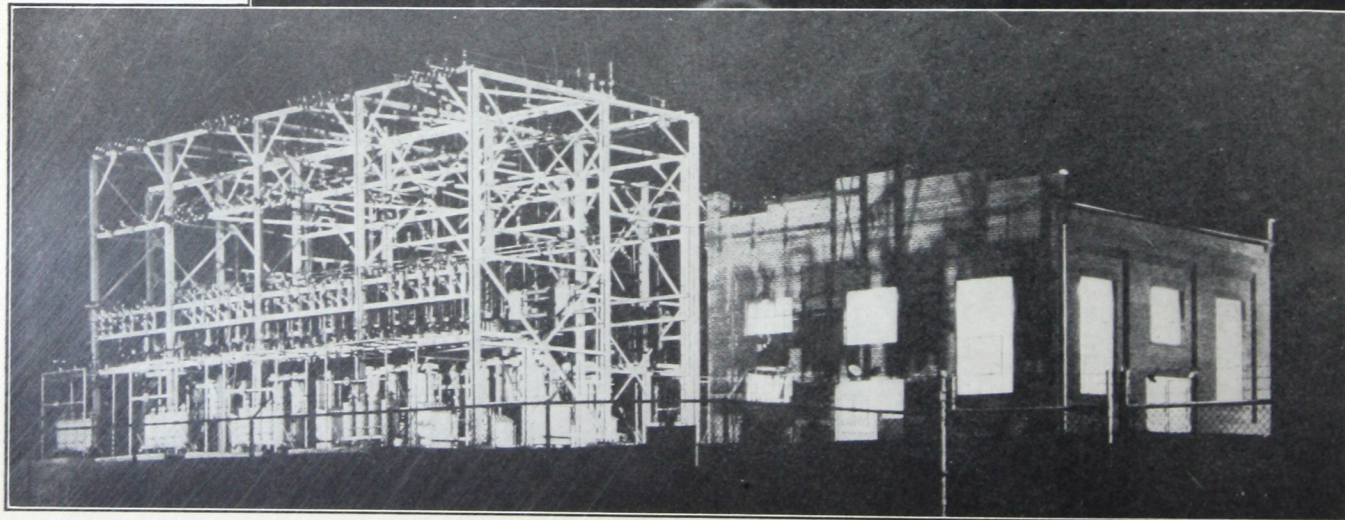


Fig. 69—(Below) Night View—Substation Equipped with Floodlighting Projectors



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Fig. 70
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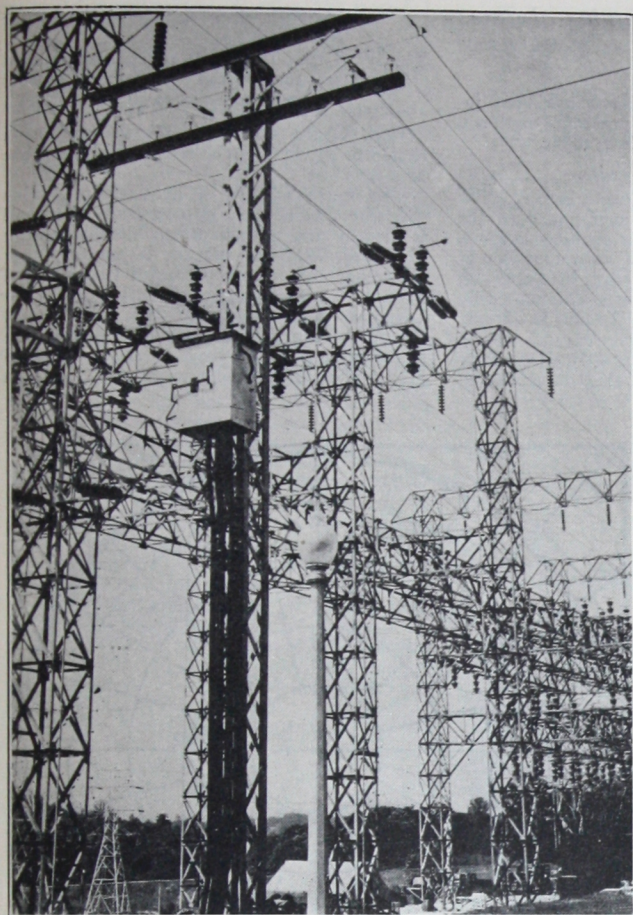


Fig. 70—Day View—Outdoor Substation Equipped with GE Form 33 Novalux Combination Street and Floodlighting Units

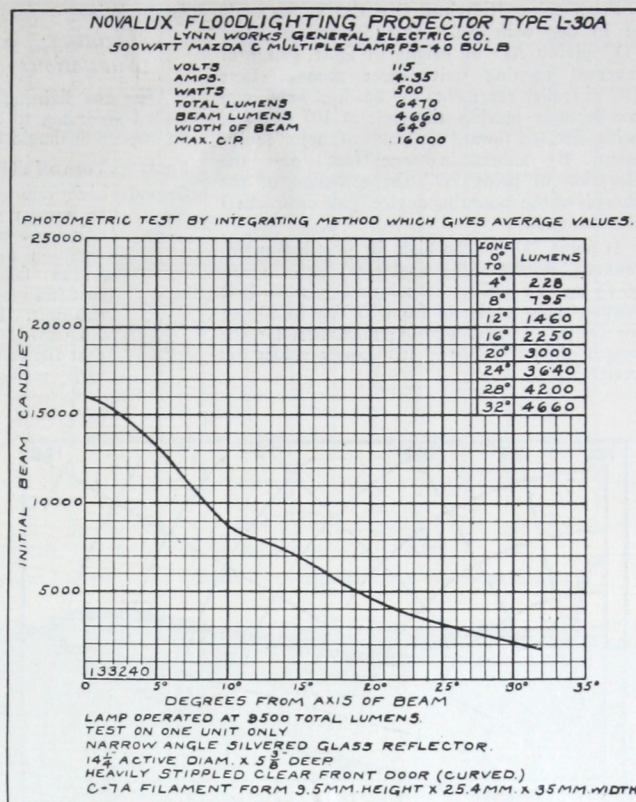


Fig. 71—Photometric Test Curve for GE Type L30A Novalux Floodlighting Projector

HOLOPHANE COMPANY, INC., NEW YORK, N. Y.

Inverted Method of Lighting Outdoor Substations

The ideal system of lighting outdoor substations should have the following qualities:

- 1—High vertical component of light.
- 2—Absence of glare.
- 3—Accessibility for relamping.
- 4—Absence of sharp shadows and dark pockets.
- 5—Low permanent depreciation.
- 6—Low initial and maintenance cost.
- 7—Flexible light distribution to suit various conditions of station design.

Substations located at the main generating plant and those of appreciable size isolated from the main plant present a lighting problem, the solution for which calls for lighting equipment whose distribution can be readily adapted to the structural design of the station. In general, the equipment in center bays of large substations may be lighted with units having a symmetrical (circular) light distribution (Figs. 72 and 73), while equipment in the outer bays may be treated with units having an asymmetrical (fan-shaped) distribution (Fig. 75).

In some instances the bays are long and rectangular in shape and the lighting of such requires a distribution in which the maximum candlepower values are along the longitudinal axis of the bays (Fig. 74). It will be seen by comparison that a distribution of this kind results in higher candlepower values along the

longitudinal axis of the bay than would a symmetrical light pattern (Figs. 72 and 73) due to the concentration of the light flux into a smaller area. The benefit of flexible light pattern is clearly shown in the above instance since if a unit having a symmetrical distribution (Figs. 72 and 73) were used in the rectangular area, the light which spills out the 2 sides of the bay would be entirely lost, whereas with the 2 way distribution (Fig. 74), the light which would have been spilled is confined to zones where it will add to the candlepower values along the length of the bay.

Small substation structures of one or two bays and of average height may be treated with one substation refractor for lighting the disconnects, the spill light being adequate for general lighting of the surrounding area. Another solution might be to mount "Wide-Spread" light refractors at the 4 corners of the station, using either bracket or pole mounting. A description of suitable brackets is given further in the text.

Procedure for Designing Inverted Lighting System for Outdoor Substations

It has been generally proven through past experience that if the major locations such as disconnect switches, air brakes, etc., are properly accounted for in an inverted lighting system design, the less important points will be taken care of automatically.

The inverted lighting unit consists of a cast metal fixture part supporting a Holophane prismatic refractor of either symmetrical or asymmetrical light distribution, the latter being

protected from the elements by a blown glass globe (either clear or rippled). Due to the fact that the Holophane refractor possesses certain adjustable optical characteristics, provisions are allowed in the fixture design for raising or lowering the lamp socket.

Referring to distribution curve, Fig. 72, it will be observed that the beam of maximum candlepower occurs at 107 deg. By lowering the socket position, this beam of maximum candlepower may be shifted as far as 115 deg. Conversely by raising the socket position, this beam may be shifted to 100 deg. For design purposes it is well to accept the 107 deg position as fitting the conditions in preliminary calculations as it constitutes an average and allows leeway for change in the event the mounting height of the unit calculates to be either too high or too low for practical maintenance purposes.

Design Procedure

Scan plan and elevation blueprints of the station under consideration, marking in colored crayon the locations of major importance such as disconnects, air brakes, etc. Study locations and mark positions where lighting units would take care of at least 2 sets of major equipment, preferably more. This point should be a column of the structure if possible, otherwise pole mounting is necessary. The solution from this point on is graphical.

Draw horizontal base line AB, Fig. 76, proportional in length to the horizontal distance from equipment to mounting point of unit. Erect perpendiculars AD and BC at each end of base line AB and on BC scale off the mounting height of major equipment above ground.

From point "C" draw line CD at an angle of 73 deg with BC. This determines point "D" giving AD or height of light center of inverted lighting unit above ground. Line DC in reality represents the beam of maximum candlepower leaving the unit at 107 deg and being directed toward the point of major equipment. By subtracting one foot from the elevation of point "D" the elevation of the threads of the mounting device (pole or bracket) is determined.

If point "D" is too high for practical maintenance, resolve using angles of from 73 deg to 65 deg for DCB. If point "D" is too low, resolve using angles of from 73 deg to 80 deg for DCB. A good working maximum for the length of line AB is 50 ft. Lesser values are preferable.

Instructions for Adjusting Inverted Lighting System for Outdoor Substations

After the lighting equipment has been installed according to design procedure outlined, an inspection should be made at night.

First: Turn off all lighting units.

Second: Light one unit. Loosen locking collar at bottom of the unit and turn the unit in clockwise or counter-clockwise direction until the maximum illumination falls on the disconnecting switches intended to be illuminated by this unit. In case the unit is Catalog No. 043772 (Asymmetric type) be sure that the refractor is oriented properly with respect to the disconnecting

switches before tightening up on adjusting collar.

Third: Turn out the unit adjusted as outlined and turn on the second unit following the same procedure as already outlined.

Each of the units used on the substation should be adjusted in the foregoing manner, one at a time.

The desirability for a lighting unit which will direct light both upward and downward is met by the advent of the double bracket unit, Fig. 79. The bracket is made of cast aluminum and is so constructed that one end fits a 4 in. cast aluminum outlet box which has 4 knockouts for 1 in. pipe. The other end of the bracket terminates in a double fitter. The fitters are of such a size to accommodate 3 pieces of Holophane glassware resulting in a

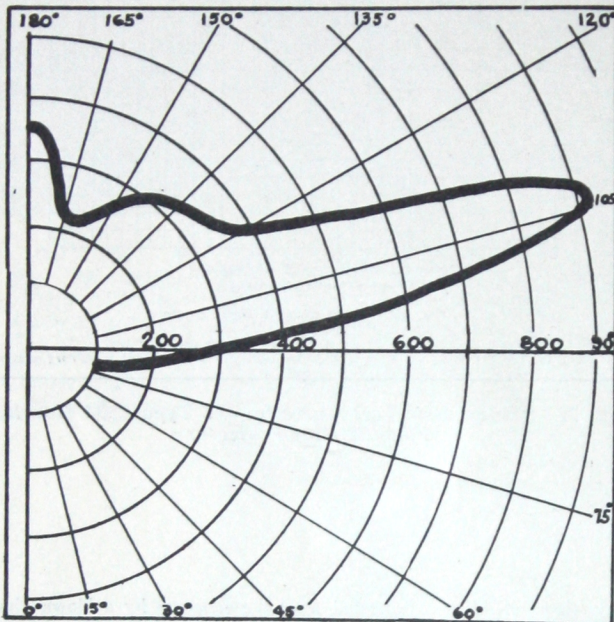


Fig. 72—Vertical Distribution Curve for Substation Unit No. 043382 with 300 W Lamps

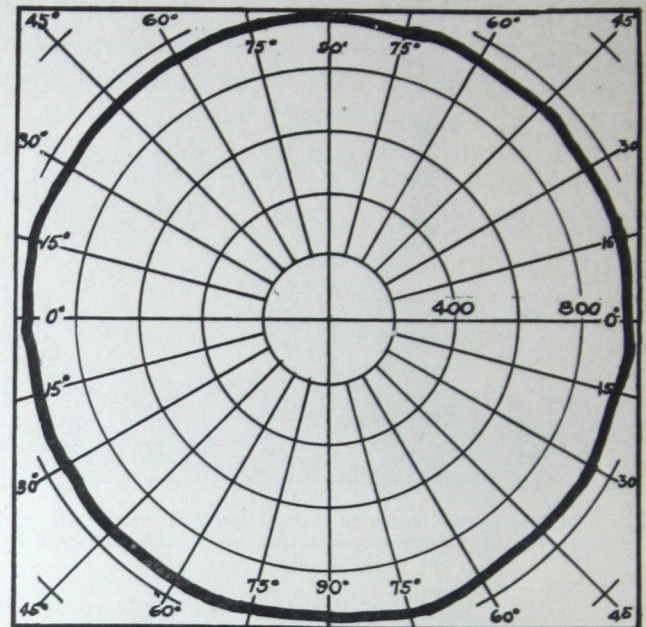


Fig. 73—Horizontal Distribution Curve for Substation Unit No. 043382 with 300 W Lamps

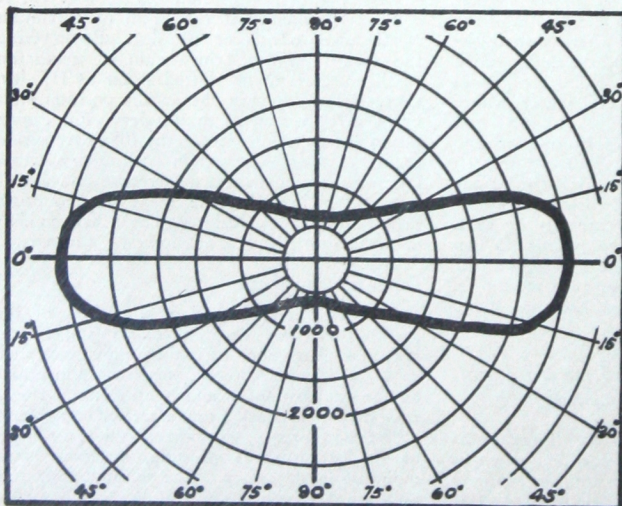


Fig. 74—(Above) Horizontal Distribution Curve for Substation Unit No. 043762 with 300 W Lamps

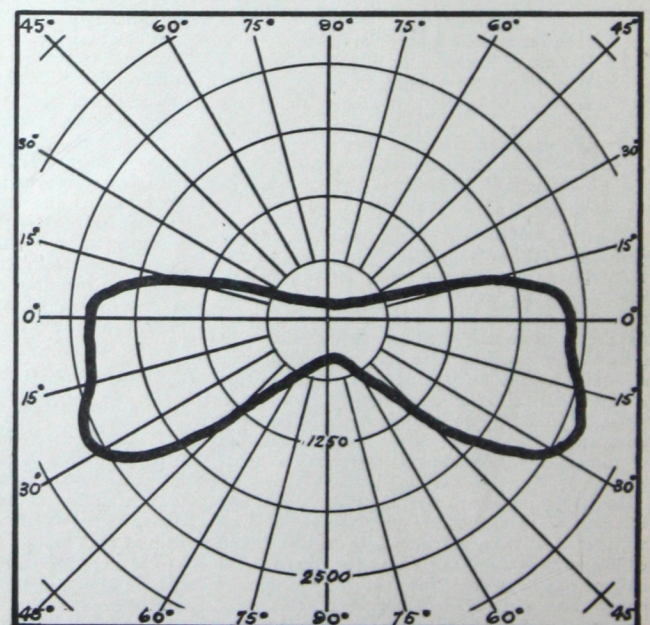


Fig. 75—(Right) Horizontal Distribution Curve for Substation Unit No. 043772 with 300 W Lamps

range of wattage from 40 w to 150 w and 3 distinctive changes in light distribution. By capping up either the upper or lower outlet of the main bracket arm, a single bracket effect may be had. The flexibility of the unit is paramount and it might be pointed out that a refractor having an extensive distribution for general lighting might be used in the lower outlet of the bracket while a light director having a concentrated distribution might be used in the upper side to light some specific piece of substation equipment.

Yard Lighting

Provision for expansion of the area covered by a substation necessitates a yard lighting installation as a reduction in accident hazard, fire hazard and prevention against theft. The substation proper generally takes up but a small part of the total area and sometimes certain portions of the remaining area are devoted permanently to storage of materials.

The Holophane lighting specified for yard lighting has been designed after the requirements were well known. The units can be placed on centers 8 to 12 times the mounting height and uniform illumination will result. The blinding effect can be reduced to a negligible quantity by mounting the units at a height from 20 to 30 ft above the ground. The unit is dirt-tight and has no permanent depreciation. There are 4 distinct interchangeable distribution types: (a) Circular; (b) 2-Way; (c) 4-Way; (d) Fan shape; so that any possible application can be efficiently met.

The Holophane yard lighting unit is made in 2

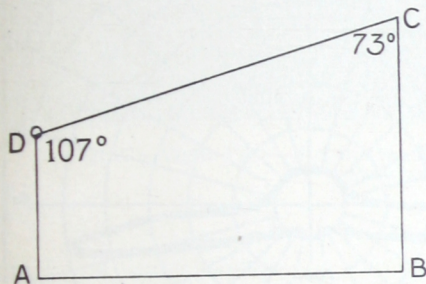


Fig. 76—Graphic Solution of Mounting Height

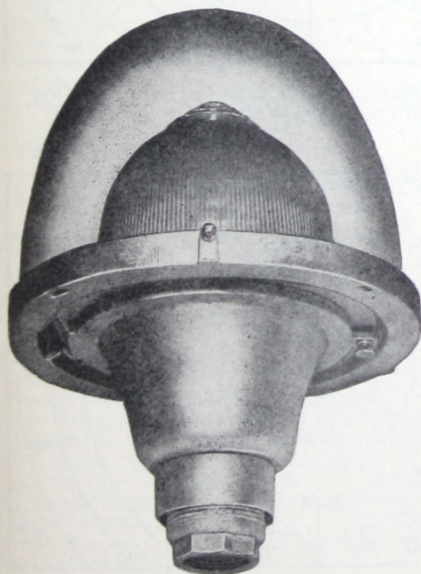


Fig. 77—Outdoor Substation Unit
Catalog No. 043382—300 W

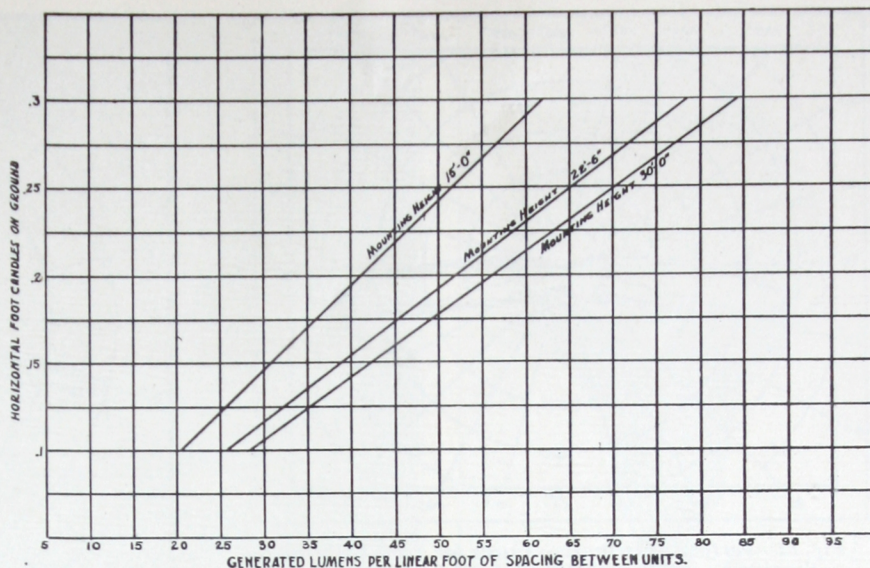


Fig. 78—Generated Lumens per Lineal Foot of Spacing between Units

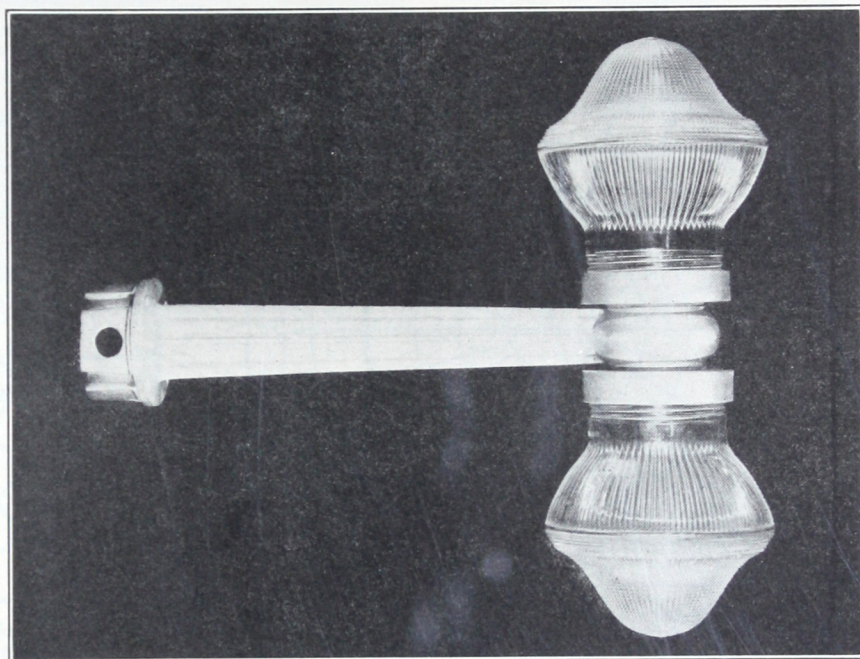


Fig. 79—Double Bracket Unit for Substation Use

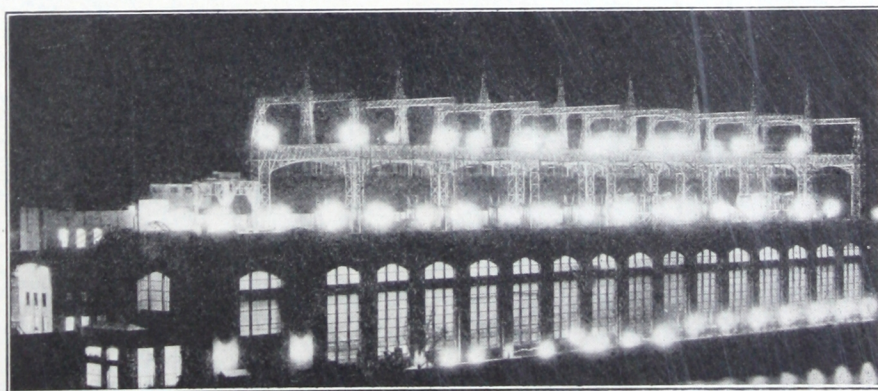


Fig. 80—Night View, Conowingo Hydro Electric Development—Designed by Stone & Webster and Day and Zimmerman

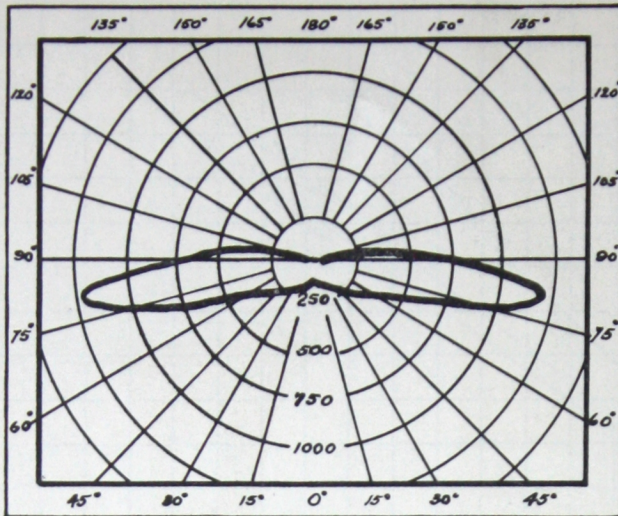


Fig. 81—Vertical Distribution Curve for Yard Lighting Specific No. 04338 with 300 W, 5,000 Lumen Lamp

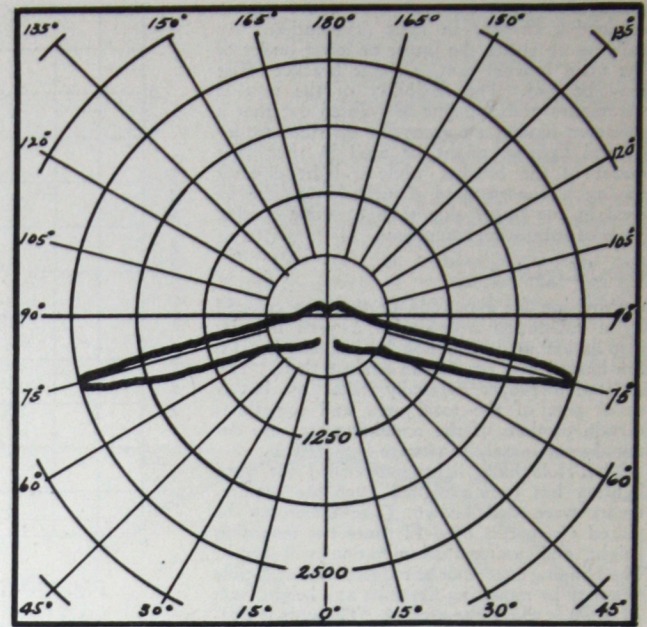


Fig. 84—Vertical Distribution Curve for Yard Lighting Specific No. 04377 with 300 W, 5,200 Lumen Lamp

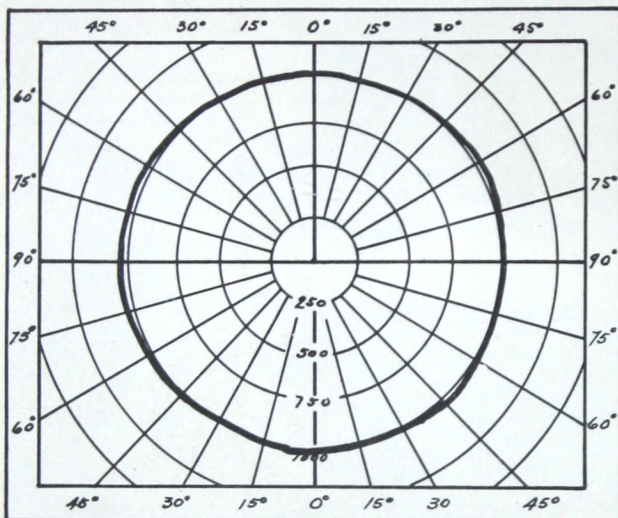


Fig. 82—Horizontal Distribution Curve for Yard Lighting Specific No. 04338 with 300 W, 5,000 Lumen Lamp

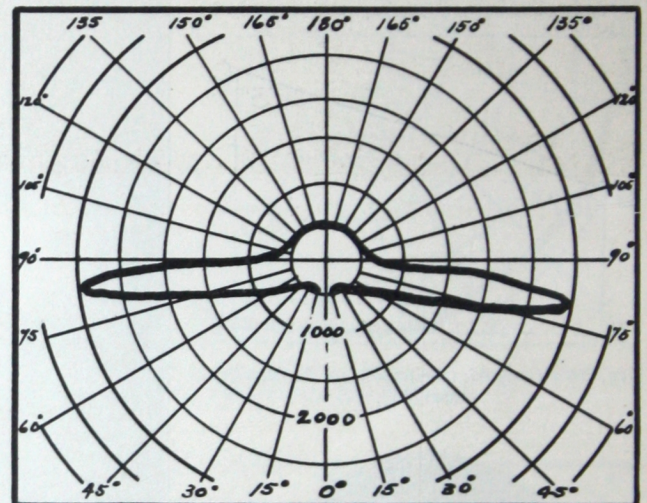


Fig. 85—Vertical Distribution Curve for Yard Lighting Specific No. 04376 with 300 W, 5,000 Lumen Lamp

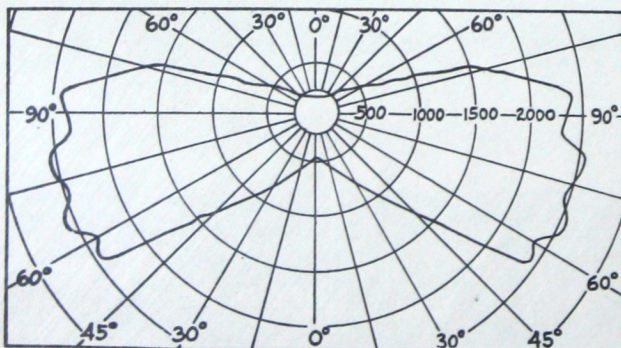


Fig. 83—Horizontal Distribution Curve for Yard Lighting Specific No. 04377 with 300 W, 5,200 Lumen Lamp

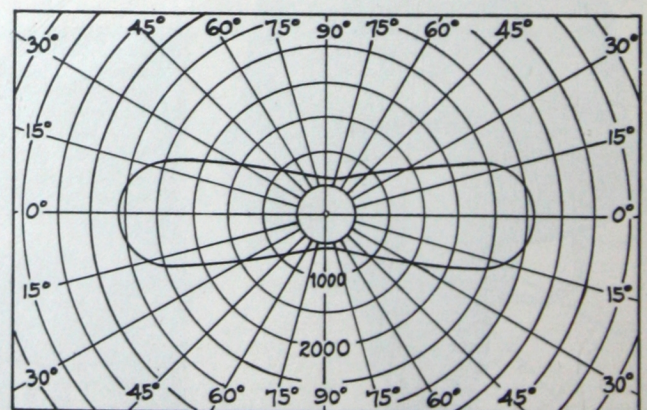


Fig. 86—Horizontal Distribution Curve for Yard Lighting Specific No. 04376 with 300 W, 5,000 Lumen Lamp

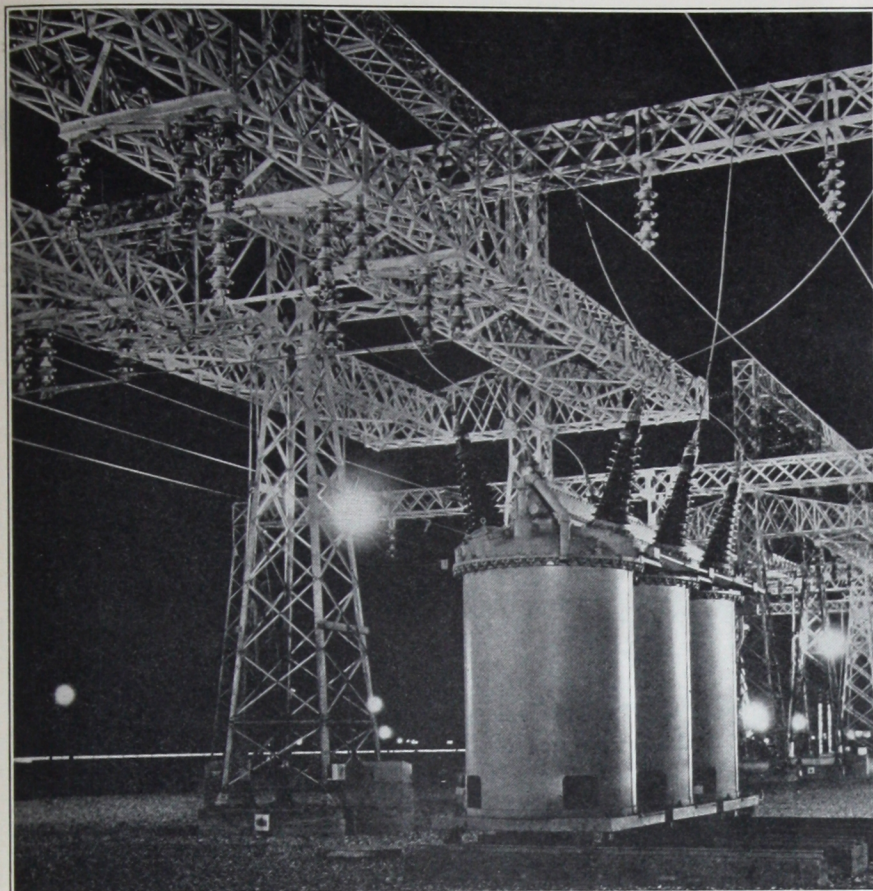


Fig. 87—Night View—Substation Equipped with Holophane No. 043382 Substation Units

sizes for the circular distribution: (a) 300 w; (b) 500 w. The 3 redirecting refractors for the 300 w sizes are of the same diameter and are interchangeable in the fixture part. The metal fixture part is made of aluminum alloy and is tapped for $1\frac{1}{2}$ in. fittings. The construction of the refractor is the well-known 2 piece type smooth outside and inside with all prisms in a dustproof enclosure. A rubber gasket locks against the fitter and refractor and makes a dust-tight fitting. Socket is adjusted by turning the lower member of the fitter which changes the socket position giving different angles of maximum candlepower.

A graph for determining proper spacing and mounting height to secure a desired intensity is shown in Fig. 78.

LINE MATERIAL COMPANY, SOUTH MILWAUKEE, WIS.

Outdoor Substation Lighting

In the public utility field it is the generally accepted practice to illuminate outdoor substations. For utilitarian purposes it is necessary that such lighting insure safe and dependable night operation, but due consideration should also be given to the esthetic appearance of the substation at night.

A properly designed substation lighting system will attract the attention of the passing utility customer and make him realize the efforts that are being made to insure him of continuity of service.

The better lighting system for outdoor substations is the one which embodies the following characteristics:

- 1—No glare (due to maximum beams being thrown upward).
- 2—Controlled lighting adaptable to various substation layouts.
- 3—Ample stray light for lighting substation yard.
- 4—Low initial cost.
- 5—Low maintenance cost.
- 6—Easily installed.
- 7—Readily accessible.

The energy used in substation lighting is not of primary importance to the operating company; therefore, careful consideration should be taken to install lighting equipment that is designed to insure adequate illumination so that both direct and indirect benefits will be realized.

By the use of the proper refractor equipment to control the light, the rays may be thrown on most any part of the substation equipment and structure.

Where the light is to be thrown in 360 deg the symmetrical light distribution is recommended.

When illumination is desired on a certain group or groups of equipment asymmetric distribution is required, and reference should be made to the various asymmetric light distribution curves of refractors, shown in Figs. 92 and 93, which we recommend for use on our outdoor substation lighting equipment.

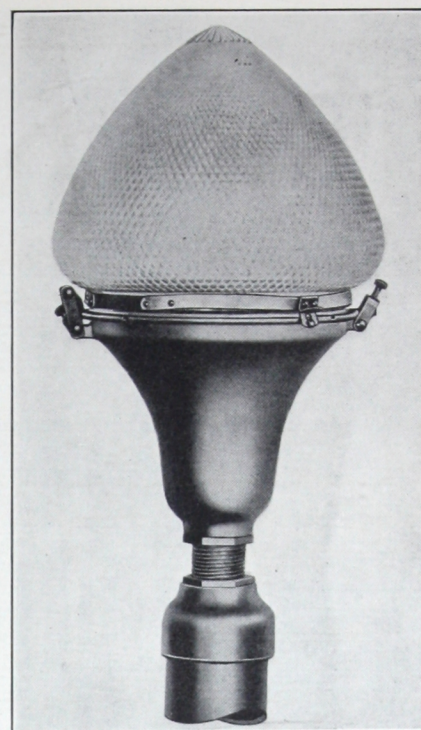


Fig. 88—Non-Ventilated Design with External Socket Adjustable Feature Recommended for Lamps as Large as 300 W (Line Material Co.)

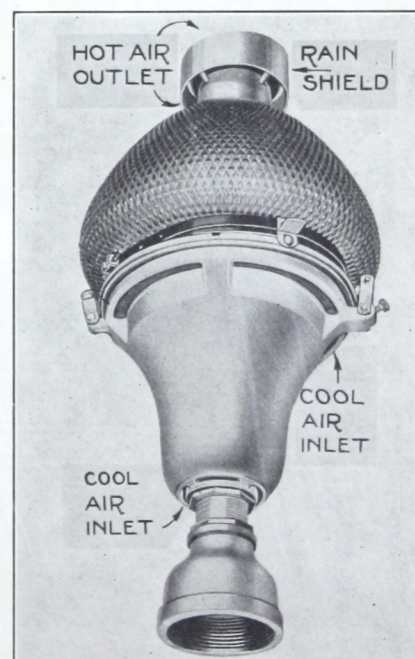


Fig. 89—Ventilated Design with External Socket Adjustable Feature Recommended for Lamps as Large as 500 W (Line Material Co.)

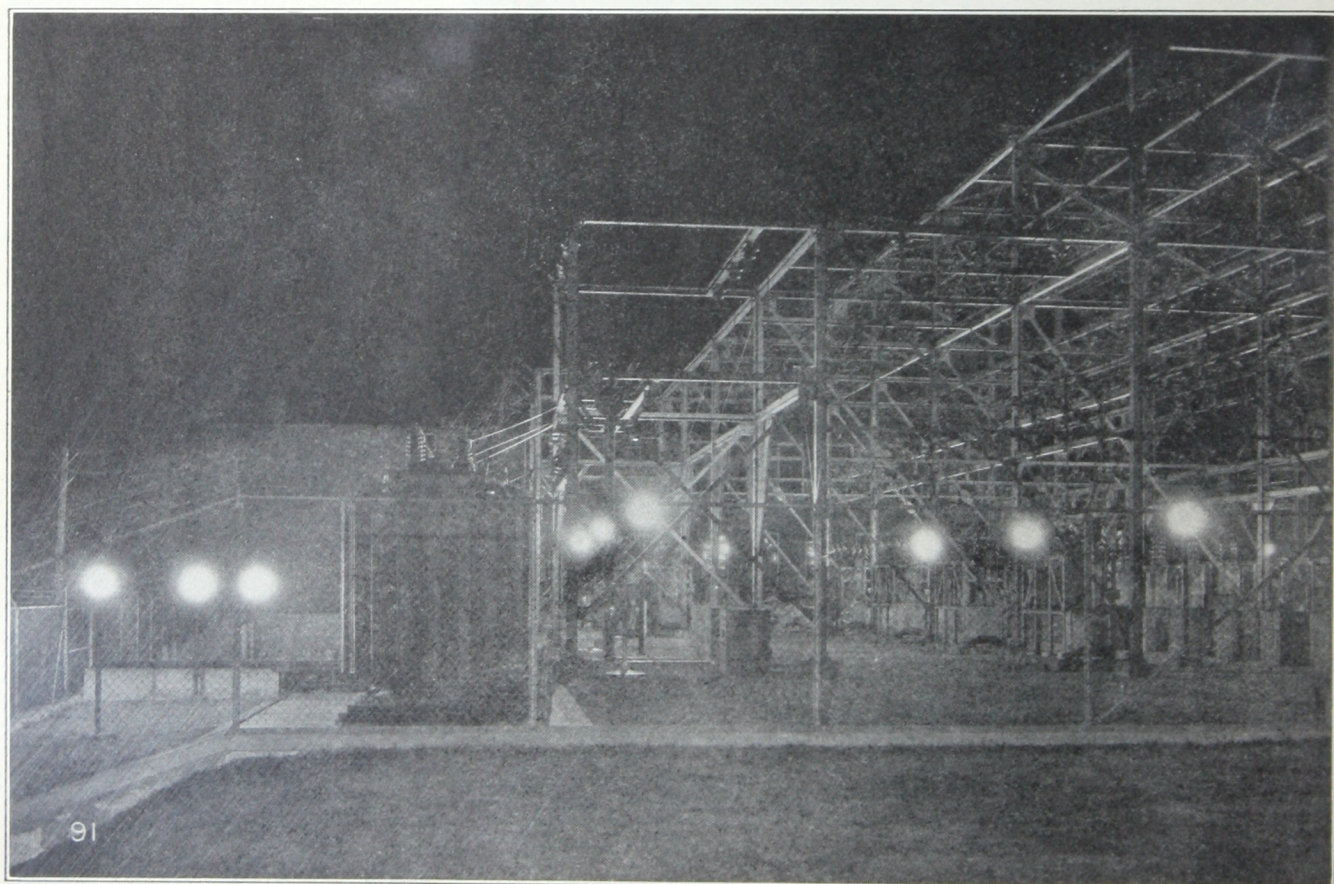
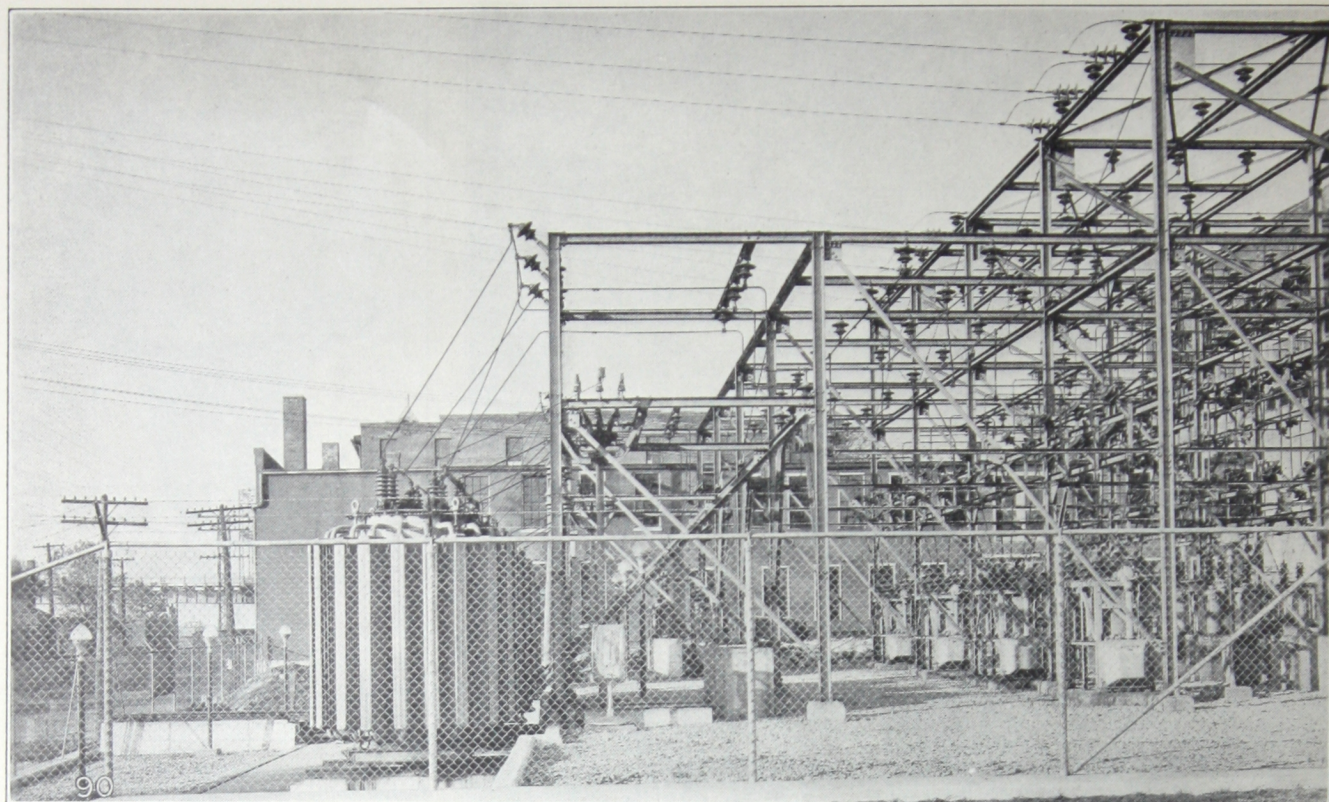


Fig. 90—Day View and Fig. 91—Night View, Substation Equipped with Substation Units

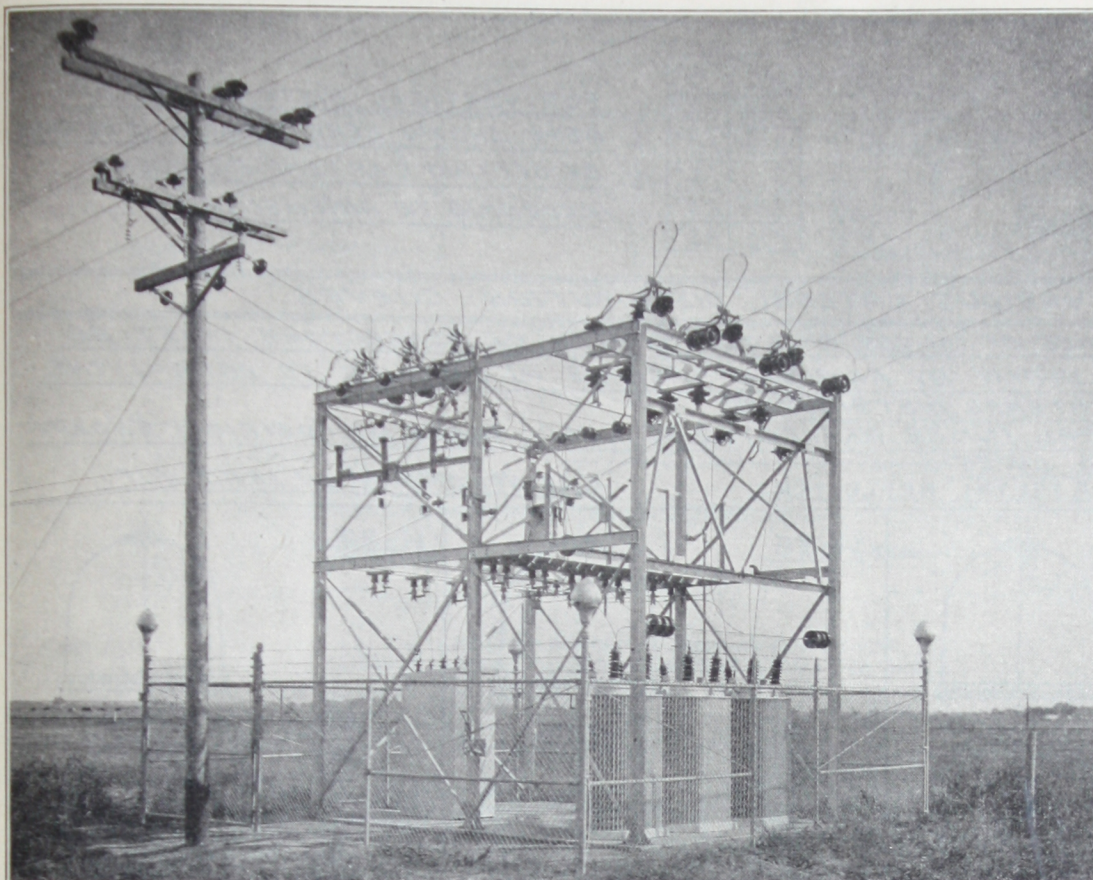


Fig. 91A—Day View, Substation Equipped with Substation Type Lighting Units

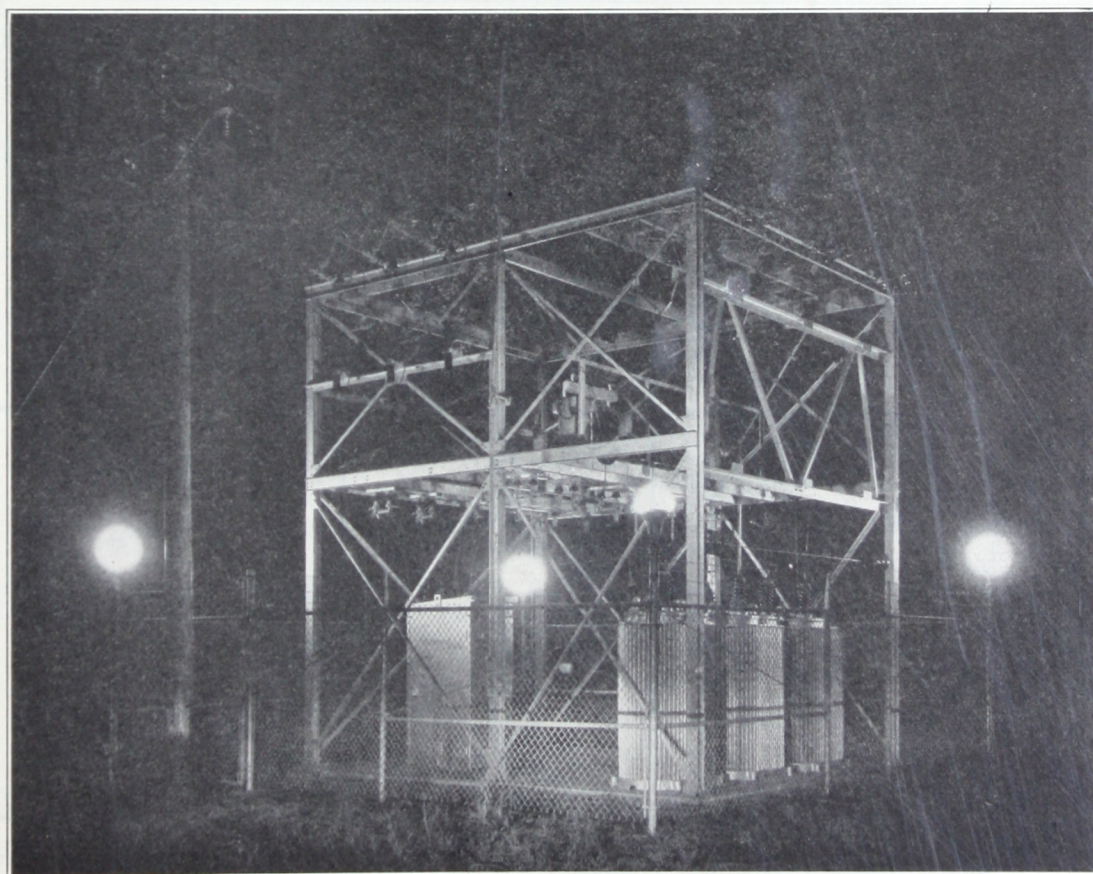


Fig. 91B—Night View, Substation Equipped with Substation Type Lighting Units

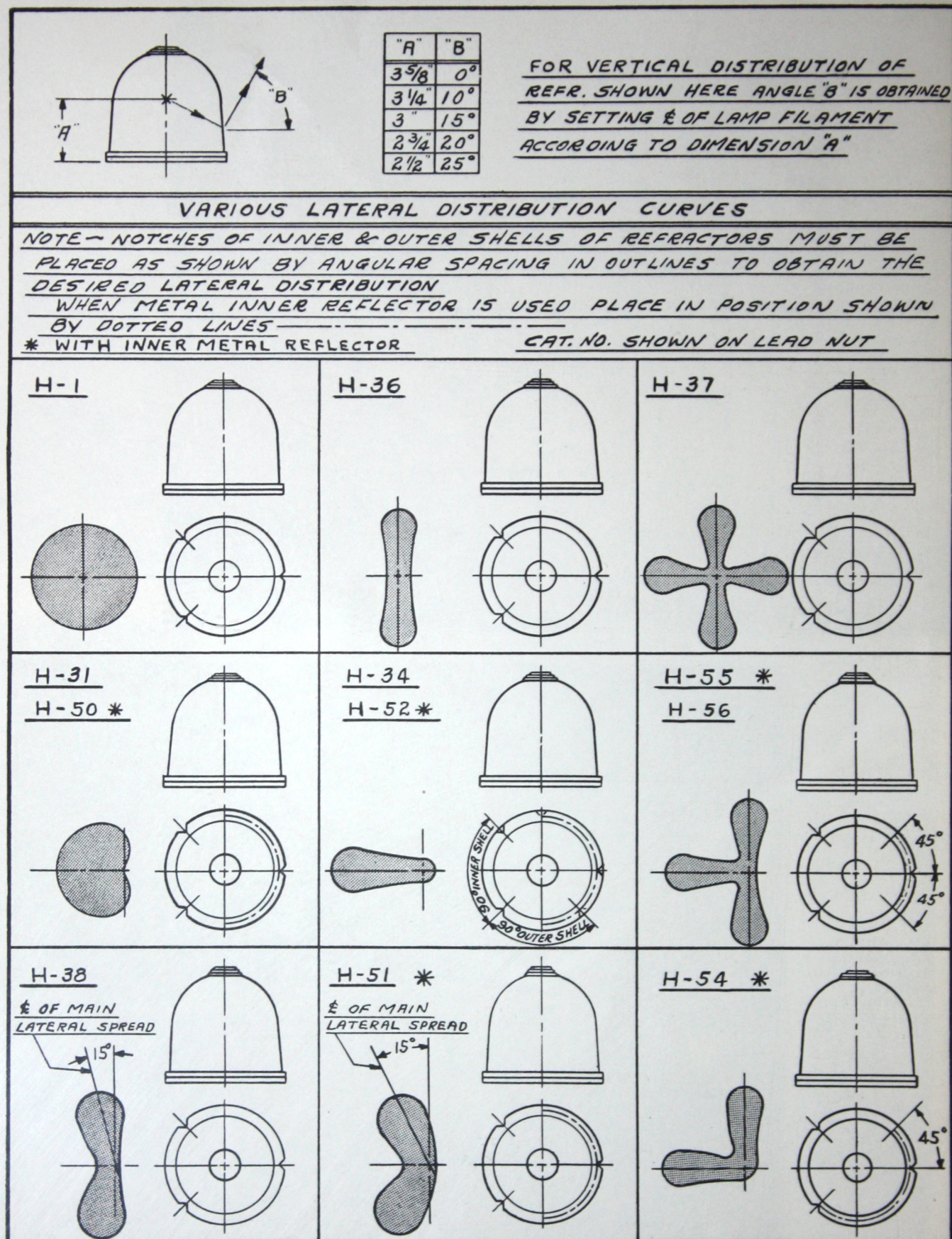
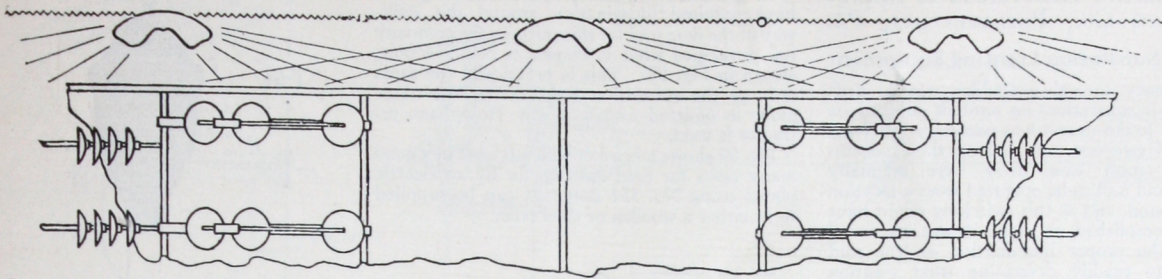
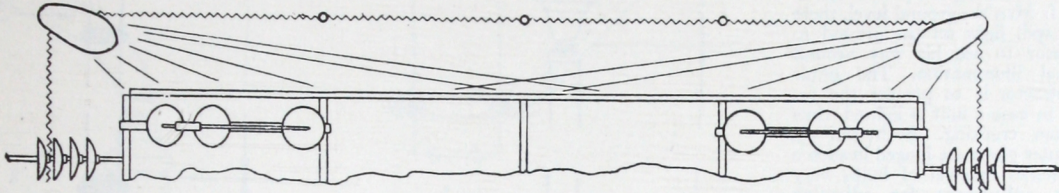


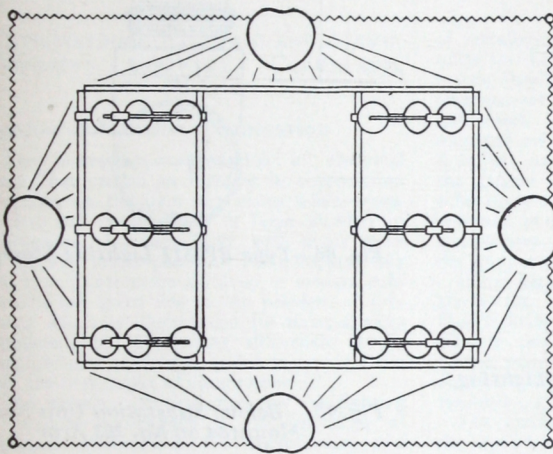
Fig. 92—Lateral Distribution Curves



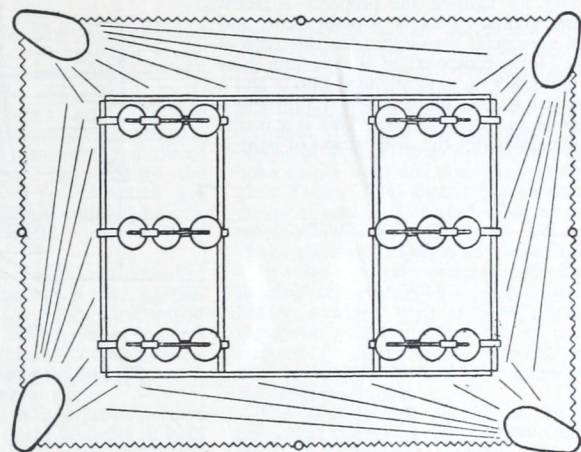
SUBSTATION FIXTURE MOUNTED ON FENCE POST
EQUIPPED WITH H-38 ASYMMETRIC REFRACTOR & F-25 SHIELD



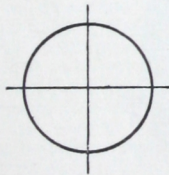
SUBSTATION FIXTURE MOUNTED ON FENCE POST
EQUIPPED WITH H-34 ASYMMETRIC REFRACTOR & F-25 SHIELD



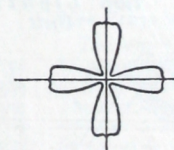
SUBSTATION FIXTURE MOUNTED ON FENCE POST
EQUIPPED WITH H-31 ASYMMETRIC REFRACTOR & F-25 SHIELD



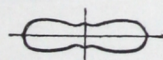
SUBSTATION FIXTURE MOUNTED ON FENCE POST
EQUIPPED WITH H-34 ASYMMETRIC REFRACTOR & F-25 SHIELD



H-1 REFRACTOR FOR GENERAL LIGHTING
INSIDE OF SUBSTATION STRUCTURE



H-37 REFRACTOR FOR LIGHTING GROUPS OF
EQUIPMENT INSIDE OF STRUCTURE



H-36 REFRACTOR FOR LIGHTING GROUPS OF
EQUIPMENT INSIDE OF STRUCTURE



H-38 REFRACTOR FOR LIGHTING GROUPS OF
EQUIPMENT INSIDE OF STRUCTURE

Fig. 93—Arrangement of Lighting Units

PHILADELPHIA ELECTRICAL & MANUFACTURING CO., PHILADELPHIA, PA.

Outdoor Substation Lighting Equipment

A tendency several years ago was to drift from indoor substations to outdoor substations and it was found that it was necessary to have a number of switches mounted on these substations. In most cases they were manually operated and had to be operated from a location on the ground, and as this switching might have to be accomplished at night it was necessary to have the proper illumination on the said switches to readily determine what position they were in.

This company designed a substation unit known as No. 528, shown in Fig. 94, using a Holophane refractor with an outer globe. This refractor is so designed that it throws a greater percentage of the light upward and if mounted about 9 ft from the ground level, there will be sufficient spill light on the ground to permit the operator to see his way around without additional illumination. The outer globe over the refractor is to protect the refractor from rain in case a unit is lighted, thus preventing it from cracking. Both the refractor and the outer globe are hinged in such a manner that it makes renewal of bulbs very simple. Also an adjustment for adjusting the light center to get the proper distribution of light from the refractor. This unit in some cases is mounted on a standard (Fig. 95) or on a bracket arm (Fig. 97).

Fig. 96 shows a unit which is used very extensively for lighting the property adjacent to steam plants. This is a plain unit and makes a very good appearance for this type of lighting. It is composed of a cast iron base with a piece of 3 in. pipe threaded into it and a cast iron capital at the top which supports a ripple globe and also canopy. This is a boulevard type globe and the distribution of light is very good.

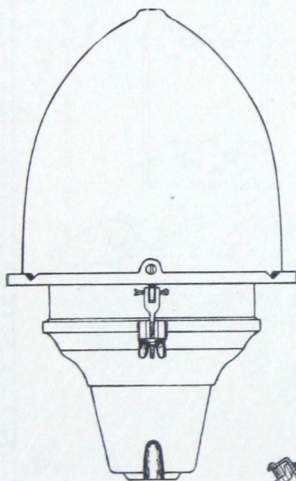
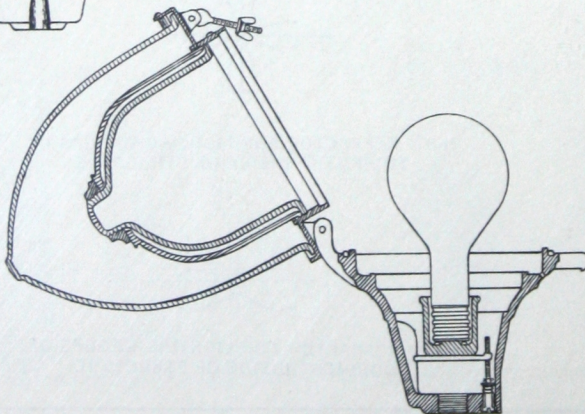


Fig. 94—(Left)
No. 528 Substation
Lighting Unit



In a number of cases, hydro electric plants have required illumination around the walkway of the dam and for this purpose the company has developed what is known as No. 354 unit, shown in Fig. 98. This is practically the same unit as the substation light except the outer globe is omitted and a 2 way Holophane refractor is used.

Fig. 99 shows a bracket which is used in a good many cases for road lighting for hydro electric plants using No. 354 unit. It can be supplied to fit either a wooden or steel pole.

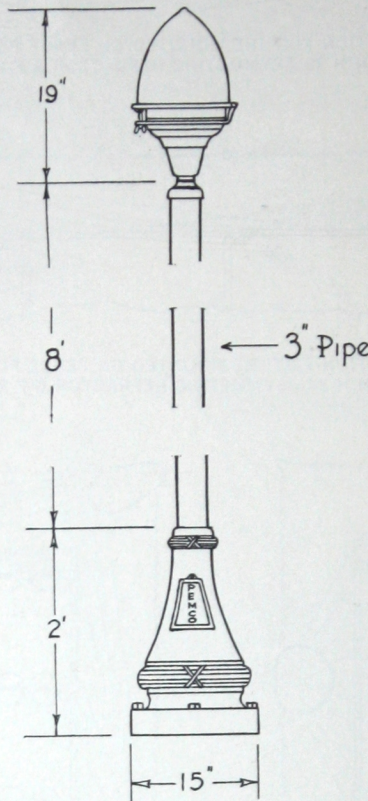


Fig. 95—Type BP2518-B Lighting
Standard

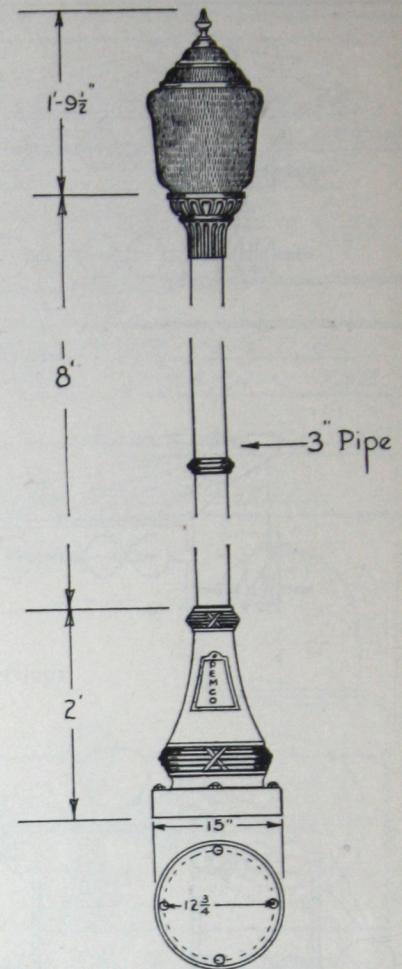
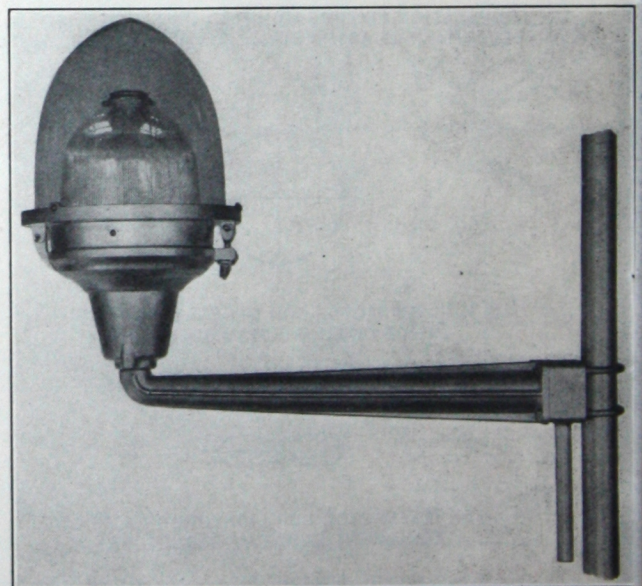


Fig. 96—Type BP2517 Lighting Standard

Fig. 97—(Below) Substation Unit No. 528
Mounted on No. 203 Arm



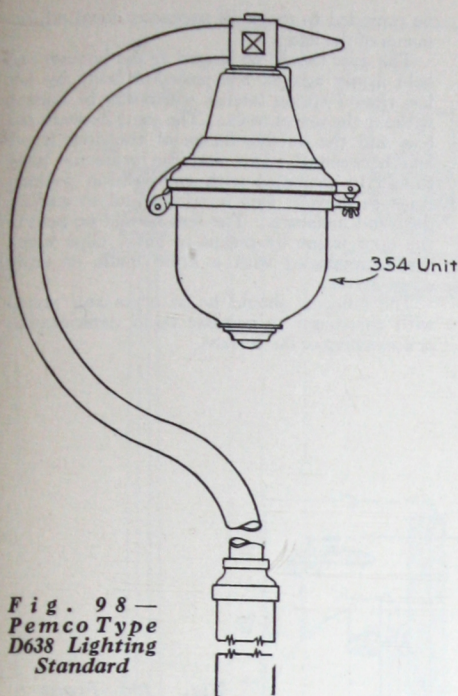


Fig. 98—
Pemco Type
D638 Lighting
Standard

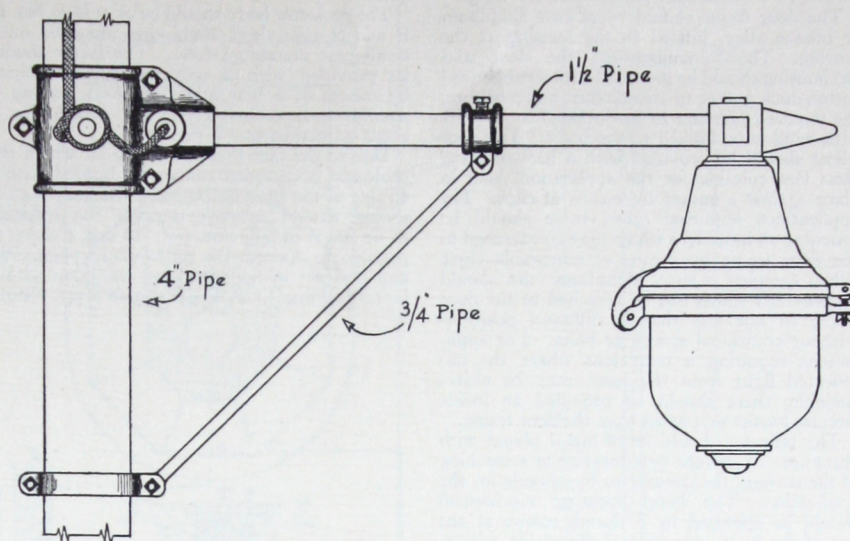


Fig. 99—Pemco Type C637 Lighting Standard, with No. 354 Unit

WESTINGHOUSE ELECTRIC AND MANUFACTURING COMPANY, CLEVELAND, OHIO

Outdoor Substation Illumination

The increasing consumption of electrical energy has caused an increase in construction programs on the part of various utility companies, and consequently a large number of substations have been built, with many more on the way to completion. The comparatively new type of structure involved in modern substations has given rise to the problem of providing adequate illumination for those already completed, and of making allowances in the design of new stations in order to supply them with the best degree of illumination.

The primary consideration in the lighting of outdoor substations is the providing of adequate illumination for maintenance and operation of equipment with perfect safety to workmen, after which lighting for advertising and good-will should be considered. Therefore, the selection of equipment will not only be governed by its utilitarian usefulness, but also by its conformity to esthetic requirements.

In planning the lighting for an outdoor substation, it is necessary to aim at good visibility in any plane throughout the structure accompanied by a minimum of glare and eye strain. The lighting units can be located either on the substation structure by means of brackets, or on separate standards or towers. It is preferable that the lighting units be mounted on standards independent of the substation structure, in order that there be no danger involved in maintaining them and so that they can be located to give the best illumination possible. The units should be mounted so as to have a light center from 8 to 20 ft above the ground and should be provided with light control features consisting of either a reflector or refractor. The reflector type units include either the ordinary floodlighting projector, directing light in only one direction, and the Duolux unit which is a street lighting luminaire having a reflector inside to control the major portion of light in the desired direction. The latter is, of course, more artistic and should be used on all installations where more than a utilitarian type

of installation is desired. The refractor type units are designed to give symmetric or asymmetric distribution of light depending upon the arrangement of equipment and area to be illuminated. The asymmetric refractors are mounted on standards located around the station just outside of the structure and direct the greater portion of the light toward the substation. The symmetric refractors are mounted on standards usually inside of the substation area. Figs. 100 to 114, inclusive, show the equipment described.

It has been found that of the units described above the most satisfactory is the Duolux Floodlighting unit mounted on Hollowspun Granite standards. In this standard a push button switch and a receptacle to take a separable attachment plug is provided as a convenience outlet for extension cords.

The spacing of the units is dependent upon the area to be illuminated, the quantity of light desired, the location of equipment within the structure and the elimination of shadows. It is impossible to give exact recommendations as to spacing of units as every installation will have certain peculiarities which will require detailed study. It can be said, however, that, in general, lighting units should be arranged symmetrically to eliminate dense shadows.

The Lighting Unit

The lighting unit should possess distinctive artistic qualities and should harmonize with the ornamental standard so as to present a pleasing and attractive appearance in the general view of the street. The lighting unit should consist of a globe, globe-ring, canopy and a means for securing the canopy to the globe. The assembly should be arranged to permit ready access to the interior of the unit in order to facilitate cleaning and lamp replacements.

The globe should be of alabaster glass with rectangular protuberances on the outer surface so arranged that light from the lamp will be sufficiently diffused in the horizontal plane with very little diffusion in the vertical plane. The character of the glassware should be such as to give the unit a brilliant and sparkling appearance with minimum absorption of light.

The canopy should be glass of the same character as the globe and should have graceful

lines tapering to an ornamental final. The diameter of the canopy at its lower edge should be large enough to provide space for a rolled brass retaining band between the upper globe flange and the canopy to serve as a resilient means of attaching the canopy to the globe by the insertion of thumb screws passing through tapped holes in the band and then binding against the globe flange. This should furnish a substantial means of securing the canopy to the globe with ample allowance for expansion and contraction of the glass with changes in temperature.

In order to further decrease maintenance each lighting unit should be furnished with a globe holder provided with resilient grips to hold the globe true to its seat and to permit easy removal for cleaning or replacing the globe. The globe holder should be given a smooth coat of green enamel.

The lamp socket should be adjustable in order that it may be raised or lowered to adjust the lamp to its correct position with respect to whatever refractor may be used and to accommodate lamps of various sizes.

Within the lighting unit provision should be made so that refractor holders may be installed to properly support the latest type of refractor for asymmetric distribution of light.

The Projector

The projector should be constructed of the best commercial grade of materials, fabricated and assembled in a workmanlike manner. The unit should consist essentially of an efficient reflector mounted in a non-ventilated housing fitted with a lamp socket and a door, the assembly to be supported in a bow mounted on a base.

The body should be made of cast aluminum or bronze alloy designed to withstand hard usage and exposure to adverse atmospheric conditions, and should be supported from the 2 sides in a steel bow pivoted on a cast iron base, both to be hot galvanized. With the base fastened in a horizontal position, it should be possible to aim the projector in any direction in both horizontal and vertical planes and to clamp the unit in the desired position. When specified, an inclination stop and a rotation stop should be provided which make it possible to return the projector body to its exact original

position without reaiming after having been turned to a convenient position for servicing.

The door frame should be of cast aluminum or bronze alloy, hinged to the housing at the bottom. The joint between the door and the housing should be provided with a rubberized cotton duck gasket to exclude dust and moisture, the required pressure to be obtained by T-bolts with wing nuts, hinged to the body. The door frame should be provided with a heat-resisting glass lens suitable for the application, held in place against a gasket by means of clips. For applications requiring color, there should be provided an inner lens which may be attached to the door frame by means of removable clips. When specified, a sheet aluminum visor should be provided which can be attached to the door frame in not less than 6 different positions without additional screws or bolts. For applications requiring a clear lens where the unreflected light from the lamp may be objectionable, there should be provided an inside circular louver supported from the door frame.

The reflector should be of metal plated with chromium to prevent deterioration or scratching of the surface, the contour to be suitable for the application. The lamp focusing mechanism should be operated by 3 thumb screws at the top of the body, providing 3 dimension adjustment. In the units for 300 w or larger lamps, it should also be possible to rotate the socket in order to properly orientate the lamp filament. The socket should be spring-supported in such a way that the lamp may be pulled forward when servicing the unit and will return to its original position when released. The projectors should be designed to accommodate 150 w to 1,000 w lamps. When specified, a socket stilt should be provided for use with G-bulb lamps.

The Floodlighting Projector

The floodlighting projector should be designed particularly for railroad yard lighting or other applications where a long throw necessitates high beam candlepower.

In order to keep the weight of the floodlight as low as is consistent with good construction, the frame should be of a cast aluminum alloy and the back of spun sheet aluminum. The joint between the spun back and the cast frame should be permanently sealed with a tough and durable compound.

The door frame should also be of cast aluminum alloy. It should be hinged to the projector frame at the side and, to prevent the door blowing shut while an attendant is cleaning or relamping the floodlight, should be provided with a device which will automatically hold the door in its open position. The joint between the door and the projector frame should be provided with a gasket to exclude dust and moisture. To insure a close fit, not less than 6 T-bolts and wing nuts should be hinged to the projector frame at equal distances about the circumference and arranged to engage with forked lugs at corresponding points on the circumference of the door frame. The lens should be of special heat-resisting glass and should be held in the door frame between 2 gaskets to prevent breakage and to exclude dust and moisture.

The focusing mechanism should consist essentially of 3 externally operated thumb screws, one for adjustment in each of the 3 directions necessary for the correct focusing of the lamp. Each of these adjustments should be independent of the other. It should also be possible to rotate the lamp socket in order to turn the lamp until the narrowest dimension of the filament faces the reflector. To facilitate cleaning the reflector and relamping, the socket should be spring-supported in such a way that the lamp can be pulled forward and, when released, return to its original focal position.

The sheet aluminum projector should be used where an inconspicuous floodlight of

light weight and narrow beam divergence is required.

The projector body should be of at least No. 18 B and S gage sheet aluminum, mounted on a small cast aluminum base. The latter should be provided with a universal joint clamped by means of a bolt and wing nut, making it possible to turn the body in any direction by a single adjustment.

Due to the fact that the lamps for which the projector is designed cannot be burned within 45 deg of the base up position, the lamp socket should extend upward through the reflector at an angle of approximately 45 deg, making it possible to operate the projector in practically any position without bringing the lamp within its critical angle. A single thumb screw should

be provided to make all necessary focal adjustments of the lamp.

The door should be hinged at the bottom and held firmly against the projector body by not less than 3 spring latches which can be opened without the use of tools. The joint between the lens and the outside flange of the door frame and between the lens and the projector body should be provided with composition packing rings to prevent lens breakage and to exclude dust and moisture. The lens should be held in the door frame by means of small clips which can be removed with a knife blade or small screw-driver.

The reflector should be of brass and plated with chromium to prevent rapid deterioration or scratching of the surface.

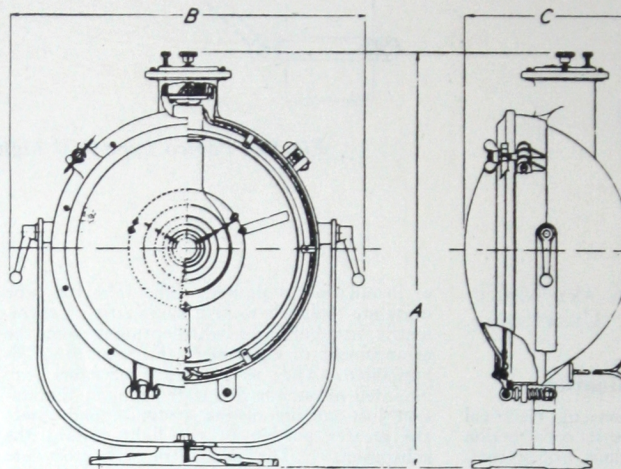


Fig. 100—Front and Side Views with Louver in Place

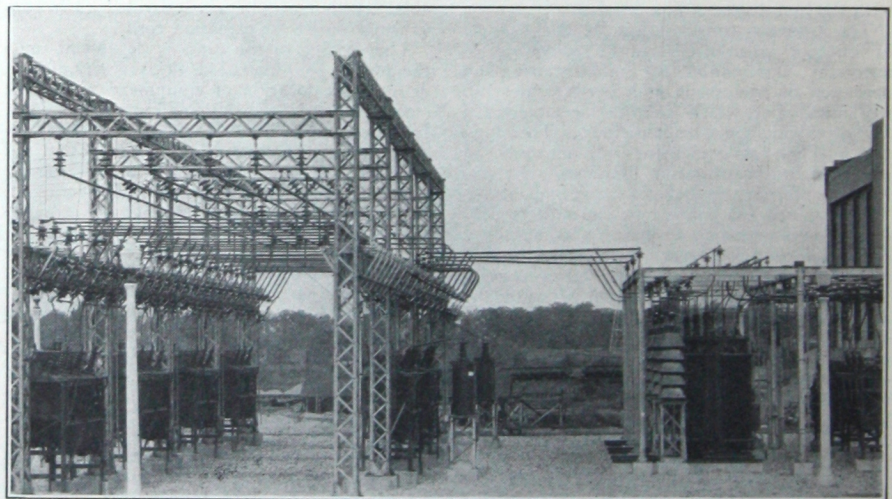


Fig. 101—Day View—Substation Equipped with Hollowspun Granite Lighting Standards

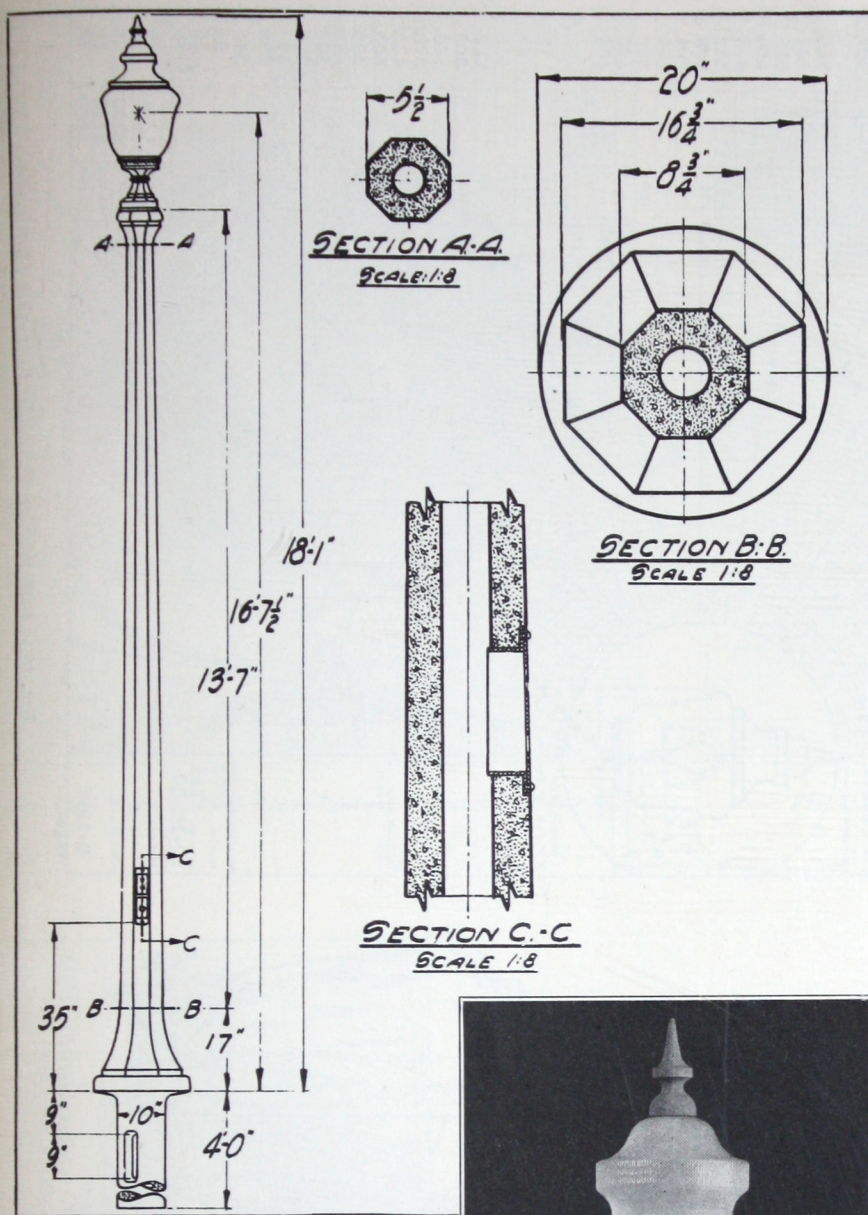


Fig. 102—Crystalux Street Lighting Unit

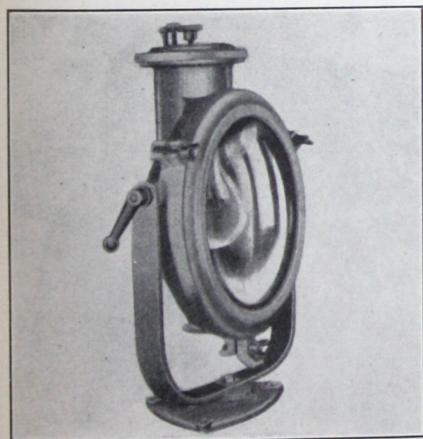


Fig. 103—Type CA-10 or CB-10 Projector

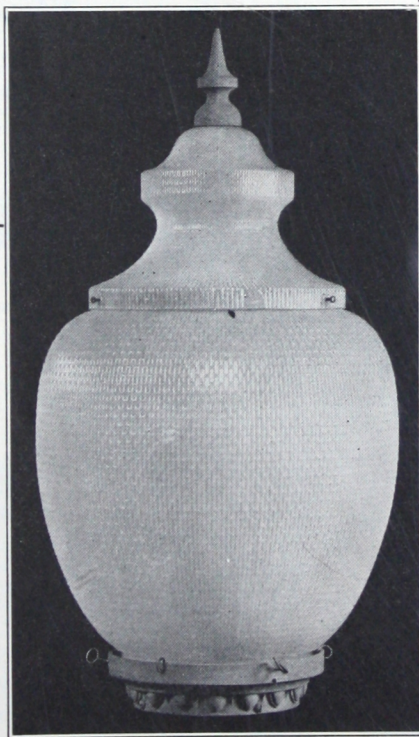


Fig. 104—Washington Lighting Unit

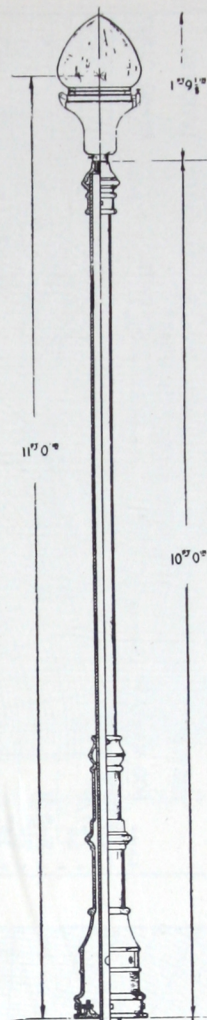


Fig. 105—Street Lighting Unit

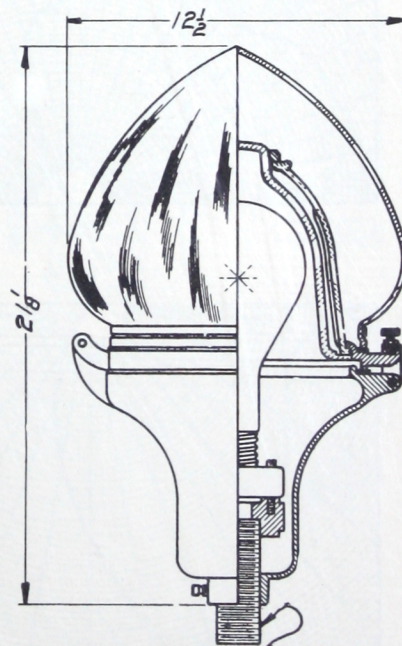


Fig. 106—Substation Lighting Unit

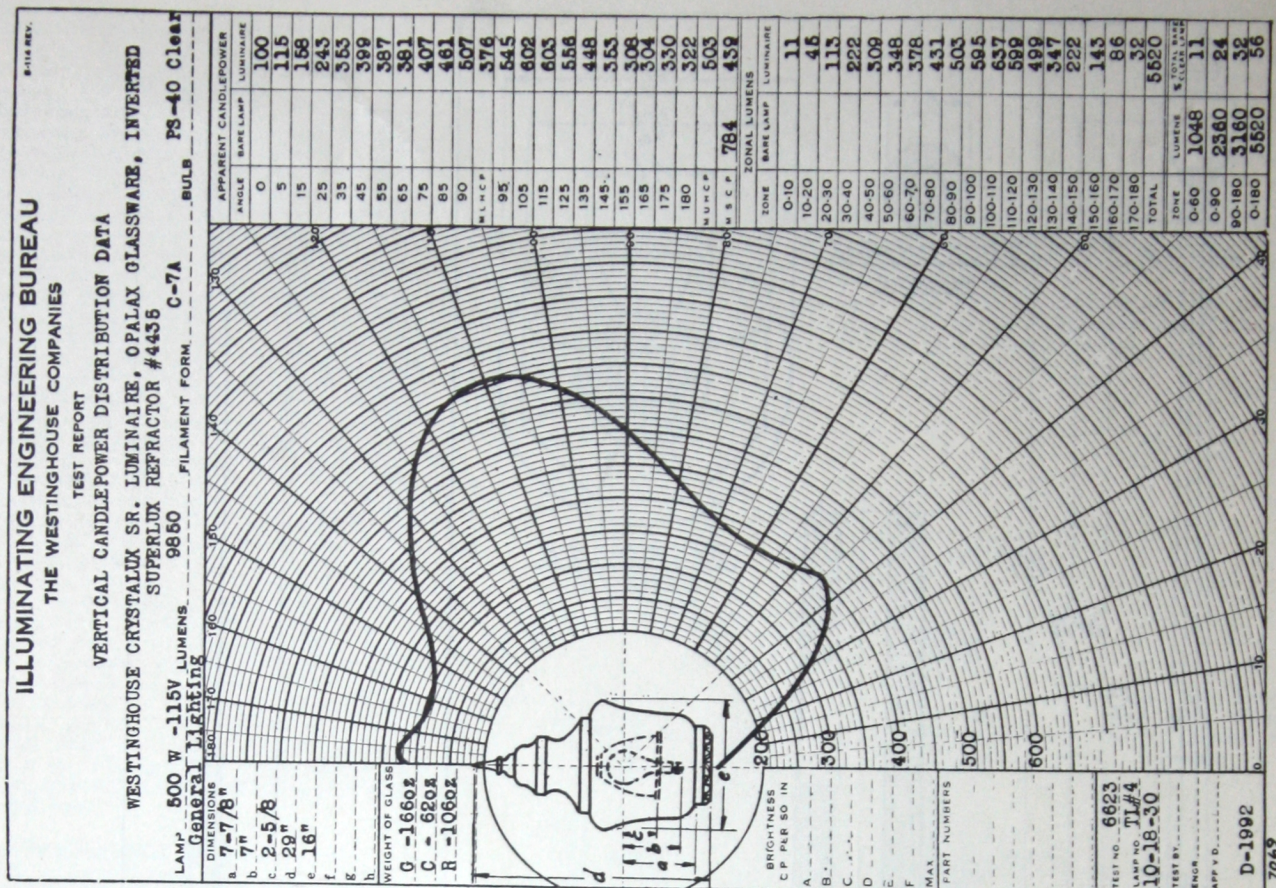


Fig. 109—Distribution Curve for Crystalux Luminaire

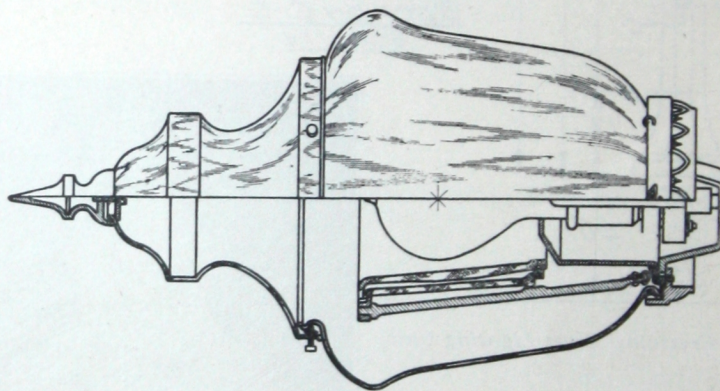
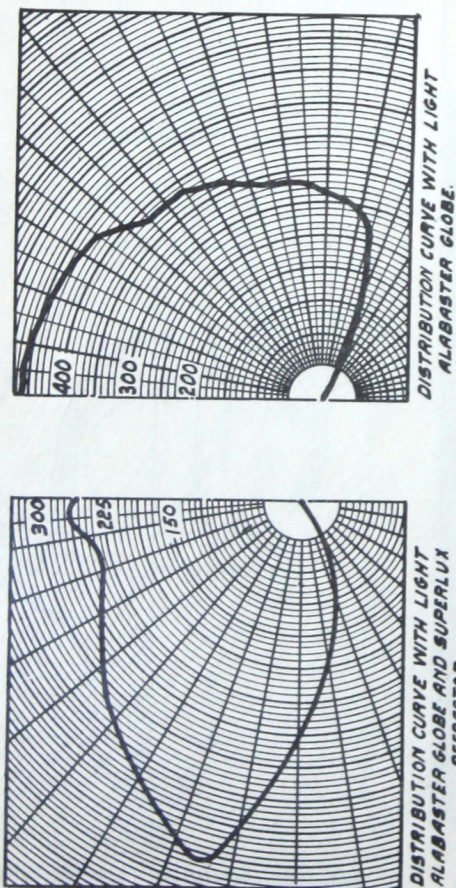
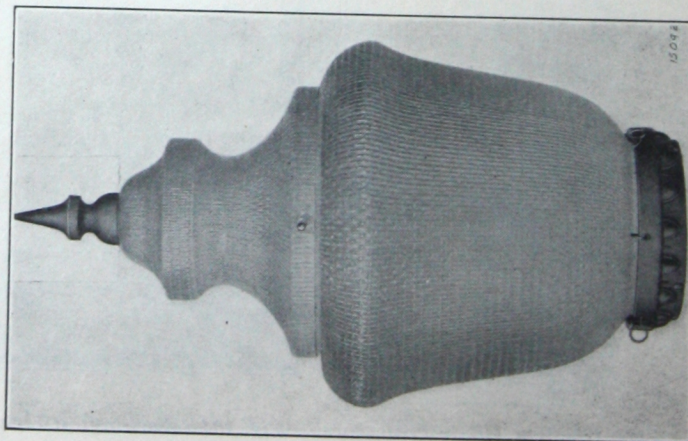
Fig. 108—Crystalux Lighting Unit—
Sectional View

Fig. 107—Crystalux Lighting Unit

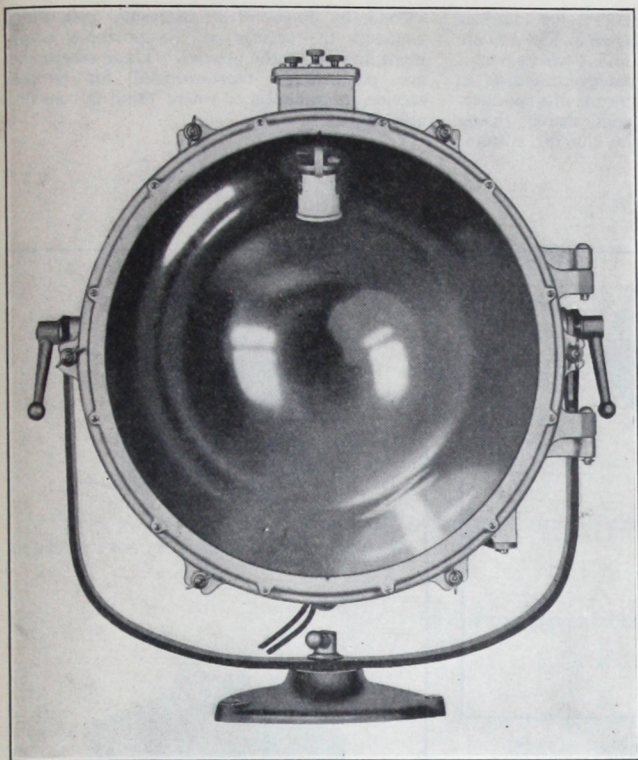


Fig. 110—Type CSA-24 Floodlighting Projector—Front View

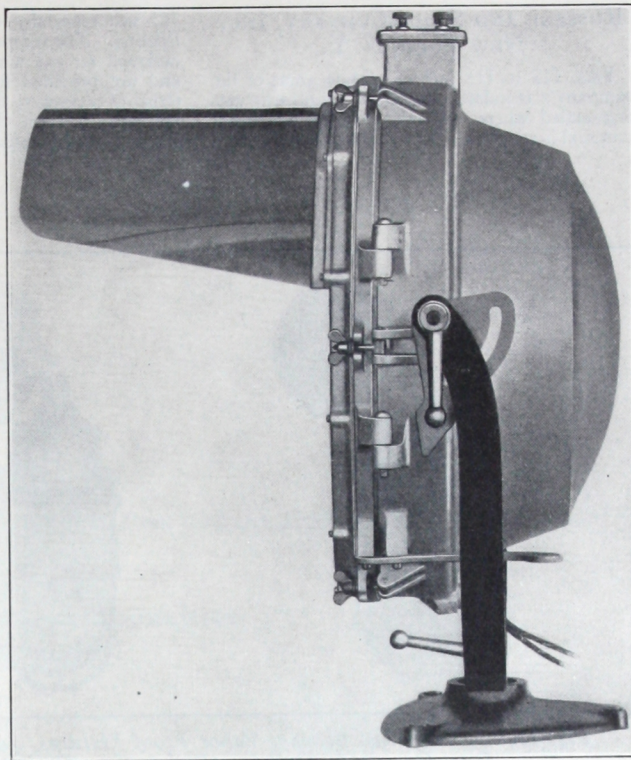


Fig. 111—Type CSA-24 Projector—Side View

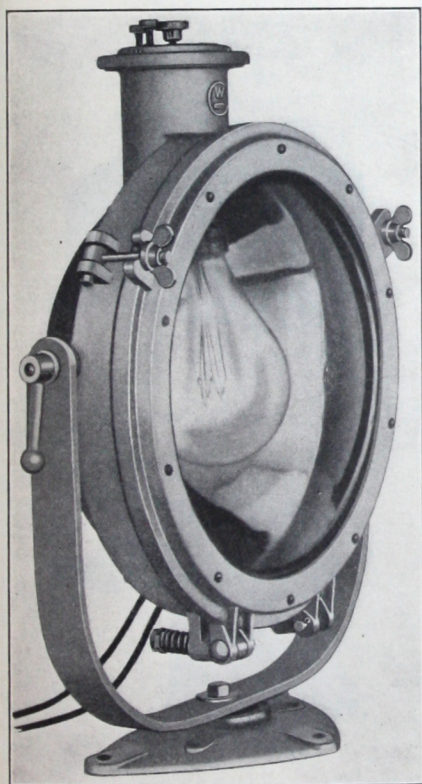


Fig. 112—Type CA-14, CB-14, CA-16 or CB-16 Projector

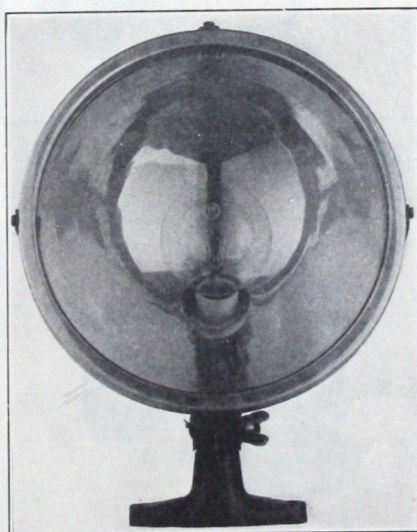


Fig. 113—Sheet Aluminum Floodlight Projector

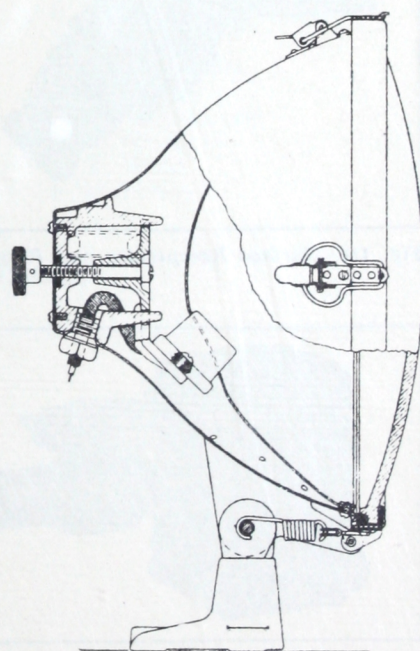


Fig. 114—Sectional View—Sheet Aluminum Projector

RUSSELL AND STOLL COMPANY, INC.
NEW YORK, N. Y.

Figs. 115 to 118 inclusive, show some of the company's standard substation equipment recommended where watertight or weatherproof material is required. The fixtures shown in Fig.

115 are especially recommended for manhole lighting. The receptacles shown in Fig. 116 are designed for use with 2, 3 and 4-wire systems and are provided for equipment-grounding in either of two ways; first, by means of a conducting path through the housings thereby using the ground connection of the conduit system;

second, by means of an additional pole which connects the casings of the portable equipment directly to the ground. These receptacles are particularly recommended for outdoor service, in manholes or where there is considerable drip.

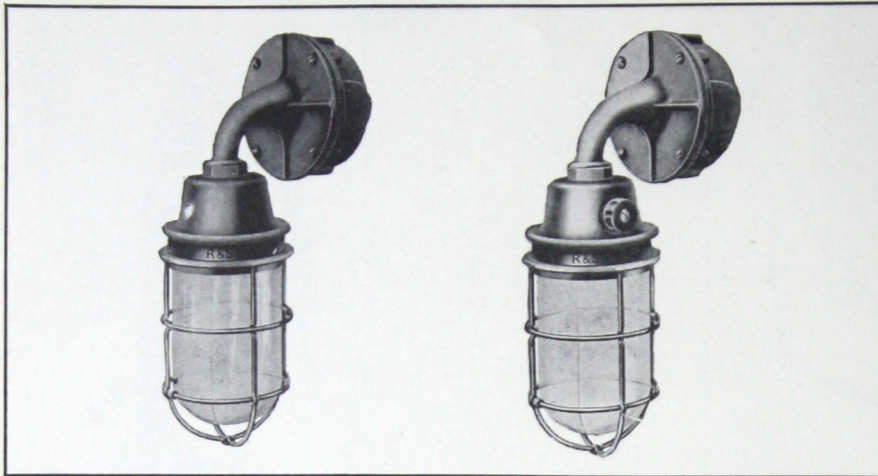


Fig. 115—90 Deg Wall Bracket Vapor Proof Fixtures, Screw Globe—(Left) Type G without Switch; (Right) Type GS with Switch

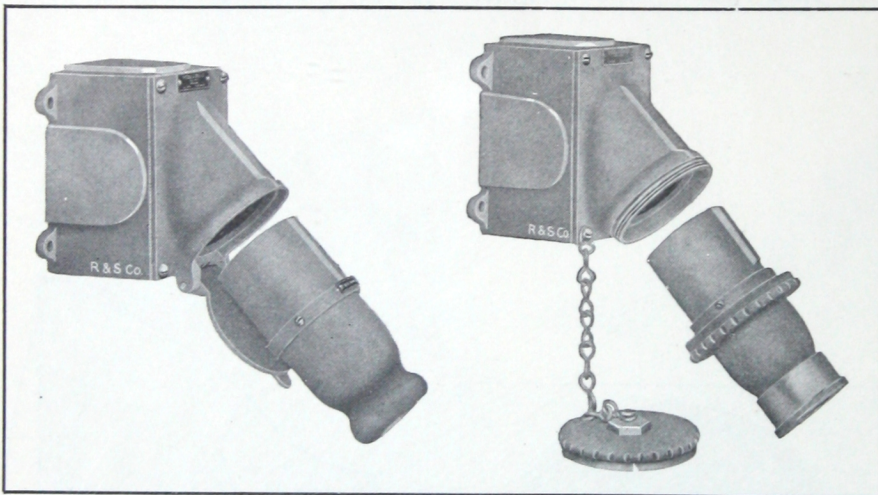


Fig. 116—Surface Receptacles and Plugs—(Left) Type A, Weatherproof; (Right) Type B, Watertight

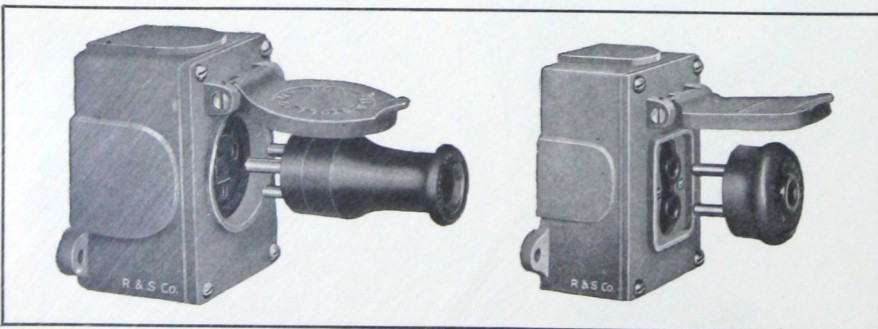


Fig. 117—Weatherproof Receptacles for Hand Portable Lamps and Small Tools—(Left) 15 Amp Capacity, Polarized with Grounding Feature; (Right) 10 Amp Capacity, Polarized or Reversible

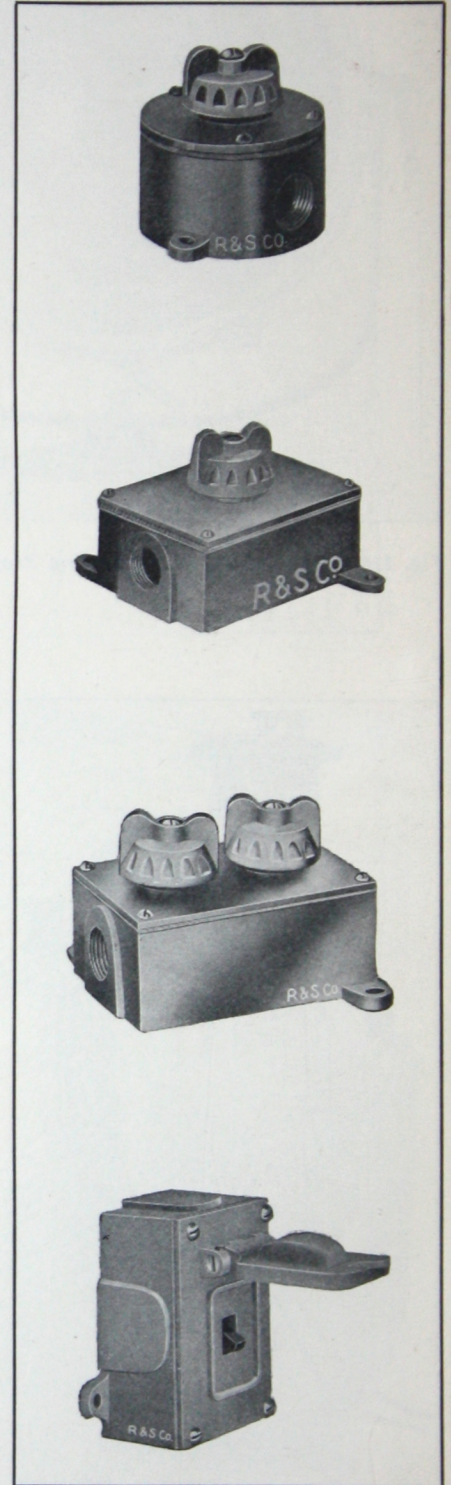


Fig. 118—Watertight Snap and Toggle Switches—Cast Brass Boxes and Covers

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Engineering National Section

(Administrative Year, July 1, 1930—June 30, 1931)

SCOPE: To consider the design, characteristics, disposition, use or operation, and maintenance of all electrical generation, transformation, conversion, utilization, control, protective and communication apparatus required or used in connection with electric power systems when located in power stations, in substations or on users' premises, for the coupling of the prime mover in the generating station to the point of utilization of the power, including the design of generating station and substation buildings, structures, circuits and devices for the housing support, connection, operation and manipulation of such apparatus.

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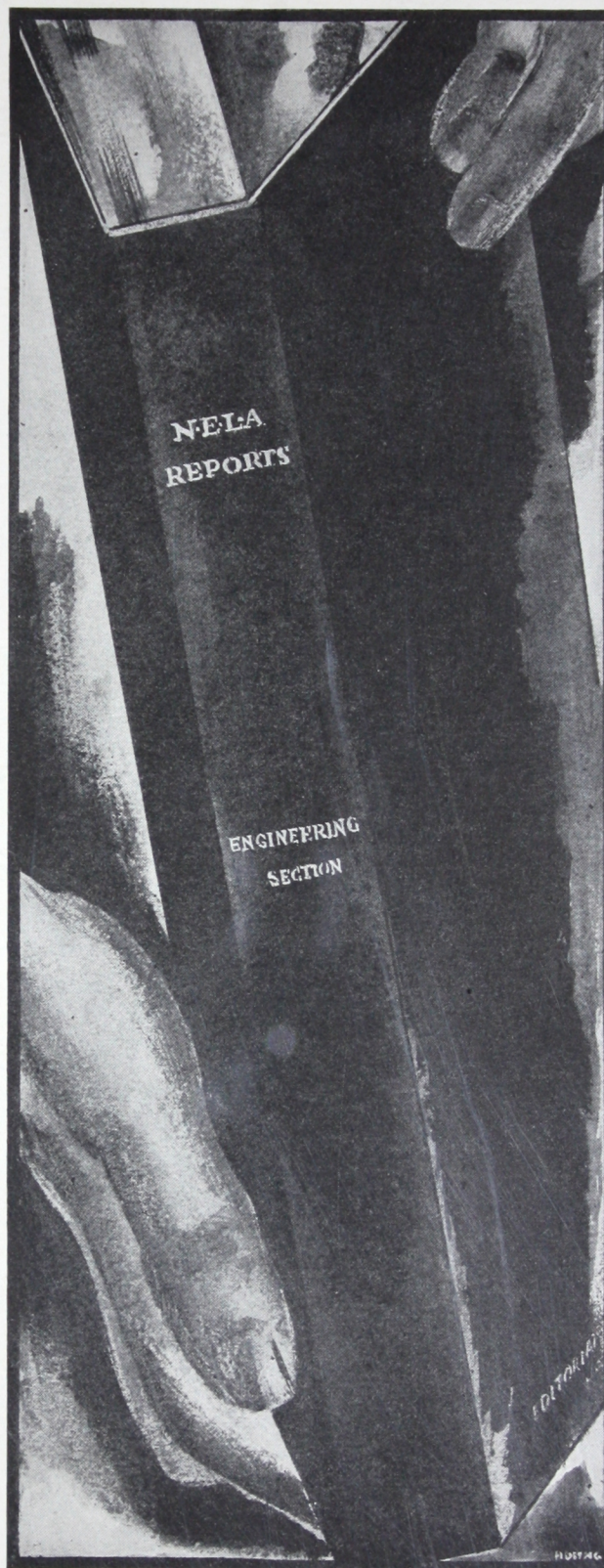
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